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HER MOST GRACIOUS MAJESTY

QUEEN VICTORIA

PASSED AWAY 22 JANUARY, 1901,

BELOVED AND MOURNED BY ALL HER PEOPLE, AFTER A GLORIOUS REIGN OF 64 YEARS.

ORIGINAL ARTICLES.

I.—British Pleistocene Fishes.

By E. T. Newton, F.R.S., F.G.S., etc.

THE search for small vertebrates in deposits of Pleistocene age has, within the last few years, been prosecuted with much zeal by several workers, and has brought to light the remains of many species of mammals, as well as birds, reptiles, and amphibia; the bones in some instances occurring in great numbers. The remains of fishes, however, have but rarely been found with the bones of other vertebrata, and never in any abundance. Some interesting discoveries of fish-remains have nevertheless been made; but the records of them are scattered through various publications, and it seems very desirable to bring all this information together.

It is sixty years since Sir C. Lyell,[1] in a paper read before the Geological Society (January, 1840), first made known that remains of fresh-water fishes had been found, by himself and Mr. J. B. Wigham, in the fresh-water deposit which occurs in the cliffs at Mundesley, Norfolk. These remains had been examined by the Rev. Leonard Jennings and Mr. Yarrel, and were referred by them to Perch, Carp, Pike, and Trout.

In the following year (January, 1841) Sir C. Lyell[2] made a further communication to the same society, in which he stated that the fish-remains noted in the earlier paper, together with some additional specimens from the same locality, had been submitted to M. Agassiz, who thought the Perch, Pike, and Trout differed from the living species, and that the remains referred to Carp were really

[1] Proc. Geol. Soc., vol. iii (1843), p. 171. Lond. & Edinb. Phil. Mag., May, 1840.

[2] "On the Fresh-water Fossil Fishes of Mundesley as determined by M. Agassiz": Proc. Geol. Soc., vol. iii (1843), p. 362. Ann. Mag. Nat. Hist., vol. viii (1842), p. 61.

a species of *Leuciscus*. No statement was made as to the nature of the remains which had been found, nor what became of the specimens.

M. Agassiz seems to have been impressed with the idea that no fossil forms could be identical with living species, and this, apparently, led him to attach greater importance to the slight differences, which he saw between the Mundesley remains and the corresponding parts of living fishes, than would be allowed by naturalists of the present day. Certain fish-remains, more recently obtained from these fresh-water deposits at Mundesley, which in all probability represent the same forms as those found by Lyell, cannot, I think, be separated from living species.

In the year 1854 Professor J. Morris[1] recorded *Esox* sp., from the Pleistocene of Copford, Essex : the specimens were jaws and teeth in the collection of Mr. Brown, and they are now preserved in the British Museum, South Kensington (Nos. 36,658–60). Other remains of Pike from Copford were presented to the British Museum by the Rev. O. Fisher (No. 4,848).

Twenty years elapsed before Mr. William Davies[2] recognized, in 1874, the remains of Pike in the collection of Sir Antonio Brady, from the Brickearth of Ilford, specimens which are now in the British Museum, South Kensington (No. 45,810). These remains were doubtfully named *Esox lucius* ?, but were acknowledged to be inseparable from that species, and in 1890 were so named, without doubt, by Messrs. A. Smith Woodward and C. Davies Sherborn.[3] During Mr. Clement Reid's[4] Geological Survey of the "Country around Cromer," he obtained a number of specimens from the classical Mundesley river bed, and among them remains of Pike, *Esox lucius* (M.P.G.—C.R. 665–6). Since the Survey Memoir was published, Mr. Reid has collected from the same place scales and teeth referable to *Perca fluviatilis* (M.P.G.—C.R. 666) and a tooth of the genus *Leuciscus* (M.P.G.—C.R. 869). We are thus able to confirm the occurrence of three of the forms recorded by Sir C. Lyell ; and there seems no sufficient grounds for referring them to other than recent species. Two or three different kinds of scales remain at present unidentified, but none of them can be definitely named *Salmo*, the fourth genus mentioned by Sir C. Lyell.

Mr. Reid's researches in the neighbourhood of Holderness,[5] Yorkshire, enabled him to record *Perca fluviatilis* from both Hornsea (M.P.G.—C.R. 1,119) and Withernsea (M.P.G.—C.R. 1,071).

In the year 1888 Mr. G. W. Lamplugh[6] gave an account of a deposit at Sewerby, near Bridlington Quay, which yielded bones of *Elephas, Rhinoceros, Hippopotamus*, etc., and is doubtless of Pleistocene age. With these mammalian bones were also found vertebræ of fishes, which almost certainly belong to Codfish. This record is the more interesting as it is the only known instance of

[1] Catalogue of British Fossils, 2nd ed. (1854), p. 326.
[2] Cat. Pleistocene Vert. Coll. Sir Ant. Brady, 1874, p. 61.
[3] Catalogue of British Fossil Vertebrata.
[4] Mem Geol. Surv., 1882, p. 126.
[5] Mem. Geol. Surv., 1885, pp. 82 and 85.
[6] "An Ancient Sea Beach near Bridlington Quay" : Brit. Assoc. Report for 1888.

marine fish-remains being found in a British Pleistocene deposit. The proximity of the sea would easily account for the presence of these fish bones, as well as for the marine molluscs which were found with them; but it also suggests the possibility of a more recent introduction. Mr. Lamplugh's careful work is, however, a guarantee that the fish bones were cotemporary with those of the Mammoth, and the condition of the specimens, which are now in the Jermyn Street Museum, is precisely the same.

Two teeth, probably of Pike, found by Mr. B. B. Woodward in the Crayford Brickearth in 1891, are now in the British Museum.

In the year 1894 Mr. F. C. J. Spurrell presented to the Museum of Practical Geology a number of specimens from the Brickearth of Erith, and among these were some teeth of *Esox lucius* (No. 5,646).

Mr. Clement Reid's most interesting work on the series of strata found at Hoxne,[1] in Norfolk, not only brought to light a large number of plants, but also of small bones of vertebrata, among which, from Bed E, were remains of *Perca fluviatilis* (M.P.G., 6,084) and *Leuciscus rutilus* (M.P.G., 6,083). In the following year, 1897, the results of Mr. Reid's similar researches at Hitchin[2] were published, and from beds on the same horizon as D and E at Hoxne he was able to record *Perca fluviatilis, Esox lucius, Tinca vulgaris, Leuciscus erythrophthalmus*, and *L. rutilus* (M.P.G., 6,301).

For some time past Mr. M. A. C. Hinton and Mr. A. S. Kennard have been searching the various Pleistocene beds at Grays Thurrock, and have obtained a good number of bones and teeth of small vertebrates, among which are many belonging to fresh-water fishes. Some account of these was read before the Essex Field Club[3] on October 27th, 1900. About a dozen otoliths, which agree most nearly with those of the Ruff, are provisionally referred to *Acerina vulgaris*?; a number of teeth doubtless belong to the Pike, *Esox lucius*; several pharyngeal bones and numerous isolated teeth are referred partly to Roach, *Leuciscus rutilus*, and partly to Dace, *L. vulgaris*; one tooth has the characteristic curved and crenulated crown of the Rudd, *L. erythrophthalmus*; and there is a single vertebra, having the peculiar tubular neural arch found in the Eel, which is with much hesitation named *Anguilla*? *vulgaris*?

There is a series of small vertebrata from Grays Thurrock in the Brown Collection in the British Museum (No. 28,079), among which are remains of fishes referable to Pike, Rudd, and probably Dace.

Many otoliths of fishes have been collected by Mr. Clement Reid from Pleistocene beds on the foreshore at Selsea; they belong to about sixteen different forms, but none of them have been definitely recognized as of living species. It is almost certain that the greater number of these otoliths have been derived from the denudation of Eocene strata in the neighbourhood, and they cannot, therefore, be included among the British Pleistocene fishes.

The discoveries of Pleistocene fish-remains on the Continent have

[1] Brit. Assoc. Report for 1896.
[2] Proc. Roy. Soc., vol. lxi (1897), p. 45.
[3] Essex Naturalist (in the press, not yet published).

been even fewer than in England. Dr. Alf. Nehring,[1] in his "Uebersicht über 24 mitteleuropäische Quartär-Faunen," mentions the following:—From (1) "Westeregeln bei Magdeburg" (p. 474), *Esox lucius*; (2) "Die Räuberhöhle am Schelmengraben zwischen Nürnberg und Regensburg" (p. 488), *Silurus glanis*, *Esox lucius*, *Cyprinus carpio*; (3) "Der Hohlefels im Achthal bei Ulm" (p. 490), *Cyprinus carpio* (or *Perca fluviatilis*); (4) "Die Fuchslöcher am Rothen Berge bei Saalfeld" (p. 495), *Esox lucius*; (5) "Die Höhle von Balve in Westfalen" (p. 504), *Esox lucius*. The age of the specimens from the first two localities is doubtful.

Dr. A. Smith Woodward has kindly called my attention to Professor F. Bassani's[2] record of *Anguilla vulgaris*, *Cyprinus carpio*, and *Leuciscus aula* from beds at Pianico, Lombardy, which Dr. Forsyth-Major assures me are of early Pleistocene age.

British Pleistocene Fishes at present known,

With the Localities from which they were obtained and the Collections in which they are preserved.

B.M. = British Museum. M.P.G. = Museum of Practical Geology.
H. & K. = Collection of Messrs. Hinton and Kennard.

Perca fluviatilis, Linn. (Perch): Mundesley, Hornsea, Withernsea, Hitchin, Hoxne (M.P.G.).
Acerina vulgaris?, Cuv. & Val. (Ruff): Grays Thurrock (H. & K.).
Salmo sp. (? Trout): Mundesley (*fide* Lyell).
Esox lucius, Linn. (Pike): Erith, Hitchin (M.P.G.); Copford, Ilford (B.M.); Grays Thurrock (B.M. and H. & K.).
Leuciscus rutilus, Linn. (Roach): Mundesley?, Hitchin, Hoxne (M.P.G.); Grays Thurrock (H. & K.).
Leuciscus vulgaris, Flem. (Dace): Grays Thurrock (B.M. and H. & K.).
Leuciscus erythrophthalmus, Linn. (Rudd): Hitchin (M.P.G.); Grays Thurrock (B.M. and H. & K.).
Tinca vulgaris, Cuv. (Tench): Hitchin (M.P.G.).
Anguilla? *vulgaris*?, Turton (Eel): Grays Thurrock (H. & K.).
Gadus morhua?, Linn. (Codfish): Sewerby (M.P.G.).

II.—On *Belinurus kiltorkensis*, Baily.

By Professor Grenville A. J. Cole, M.R.I.A., F.G.S.

In 1899 Messrs. Rupert Jones and Henry Woodward[3] stated that *Belinurus* "has not at present been found in rocks of earlier age than the Coal-measures." *Belinurus grandævus*, described in the same paper, was referred, with probability, to the Lower Carboniferous. A writer ("R. W. E.") in the *Ottawa Naturalist*[4] for January, 1900, thereupon called attention to the record of *Belinurus* from the Kiltorcan Beds of Ireland. This record is founded on Mr. W. H.

[1] Zeitsch. d. Deutsch. geol. Gesell., 1880, p. 468, where reference will be found to the original records.
[2] Atti Soc. Ital. Sci. Nat. vol. xxix (1886), p. 344.
[3] "Contributions to Fossil Crustacea": Geol. Mag., 1899, p. 389.
[4] Quoted in Geol. Mag., 1900, p. 177.

Baily's discovery[1] of "a well-marked head (or carapace), to which is attached portions of two of the thoracic segments." Dr. Henry Woodward,[2] in 1878, accepted this determination, on the basis of sketches furnished to him by Mr. Baily, who had by this time discovered a second, though distorted, specimen. The Kiltorcan Beds, it may be remarked, are of Upper Old Red Sandstone age, and are part of the 'Yellow Sandstone Series,' which passes conformably up into the Lower Carboniferous Shale. They are not, therefore, of such high antiquity as the writer in the *Ottawa Naturalist* suggests.

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Fig. 1.—Sketch of the less imperfect specimen of *Belinurus kiltorkensis*, Baily, showing the principal features visible with a platyscopic lens. Natural size. The carapace is viewed from the under side.

Fig. 2.—Sketch of the distorted specimen, viewed from the upper side with the aid of a platyscopic lens. Natural size. The details of the central portion are best seen in this example, though the whole is greatly broadened.

The question having thus been raised, I obtained the permission of the Director-General of the Geological Survey to examine the specimens preserved in the collections in the Dublin Museum. Mr. Baily's specimens have, at some later time, been relabelled as 'Limuloides'; but the carapace is certainly not of the hemiaspid type. It presents the continuous unnotched margin shown in Mr. Baily's original drawing. The better specimen is, I feel confident, presented to us from the under side, and shows more detail than has hitherto been attributed to it. The flat border, 1 mm. wide, is followed by a smoothly curving region, from which the protuberances rise which correspond in part to the glabella in the trilobites. The form of these is best seen from the annexed sketches, which, like Mr. Baily's, have been made from the original specimens. The distorted example is seen both as an external cast and in relief, and the four elevated portions stand out distinctly on it. They seem to have been highest at their margins, a rim thus occurring about a depressed area on each. This feature is also seen in Mr. Griesbach's drawings of the better known species of *Belinurus*.[3]

The eyes indicated by Baily are based on a thickening that occurs on the edge of the 'glabella,' where it descends to meet the smoother lateral area. The evidence is slight, but agrees with what is already known of *Belinurus*.

There are indications of radial ribbings on either side of the

[1] "On Fossils obtained at Kiltorkan Quarry, Co. Kilkenny": Report Brit. Assoc. for 1869, p. 75.

[2] "British Fossil Crustacea" (Palæontographical Society), p. 238.

[3] "Brit. Foss. Crust." (Pal. Soc.), pl. xxxi.

'glabella,' like those that have been attributed to impressions of the limuloid limbs.

The 'pleuræ' (if we may use the nomenclature adopted in the case of trilobites, with which these forms provide so valuable a link) are furrowed, while in *Hemiaspis* (*Limuloides*) they are unfurrowed. Traces of three segments are preserved in the more perfect specimen. Even the somewhat abrupt posterior bend, so characteristic of the pleuræ of *Belinurus reginæ*, is noticeable in the first segment of *Belinurus kiltorkensis*, and was doubtless repeated in the others.

Protolimulus (*Prestwichia*) *eriensis*, described from the Devonian of Pennsylvania by H. S. Williams and A. S. Packard,[1] is only known by its under surface; but the cephalic shield does not resemble that of the Kiltorkan specimens.

I feel, then, that *Belinurus* may safely be regarded as occurring in the Upper Old Red Sandstone of Ireland, which some authors have proposed to include in the Lower Carboniferous Series. There seems no reason to depart from the determination made by Mr. Baily and Dr. Woodward thirty years ago, a determination that has become widely known through the works of Zittel and other palæontologists.

III.—History of the Sarsens.

By Professor T. Rupert Jones, F.R.S., F.G.S., etc.

Additional Notes.—These further references and fuller quotations are here given with the view of making the History of the Sarsens, or Sarsen Stones, more complete and more easily available, especially by indicating the chronological succession of observed facts and published opinions.

§ 1. Origin and Constitution of the Stones called 'Sarsens.'
§ 2. Fossils in Sarsens.
§ 3. Localities. I. In the Counties north of the Thames: (1) Northamptonshire, (2) Suffolk, (3) Essex, (4) Hertfordshire, (5) Buckinghamshire, (6) Oxfordshire, (7) Middlesex. II. In the Counties south of the Thames: (8) Kent, (9) Surrey, (10) Hampshire, (11) Berkshire, (12) Wiltshire, (13) Dorset, (14) Somerset, (15) Devon.
§ 4. Bibliographic List.

§ 1. Origin and Constitution of Sarsens.

(See also Part i in Wilts Mag., 1886, p. 126.)

1819. G. B. Greenough, in his "Critical Examination of the First Principles of Geology," p. 112, says that the Greyweather Stones ('Greywether sandstone,' etc., p. 293), scattered over the southern counties of England, have been evidently derived from the destruction of a rock which once lay over the Chalk.

1871. In the Transactions of the Newbury District Field Club, vol. i, p. 99, Sarsens are referred to as "indurated blocks of sandstones and conglomerates."

1882 and 1885. Sir Archibald Geikie, treating of siliceous cements in sandstones, writes, "where the component particles are

[1] Packard, "Carboniferous Xiphosurous Fauna of North America": Mem. Nat. Acad. Sci. Washington, vol. iii (1886), p. 150.

bound together by a flinty substance, as in the exposed blocks of Eocene sandstone known as 'Grey-weathers' in Wiltshire, and which occurs also [Landenian, sandstone] over the north of France towards the Ardennes" ("Textbook," 2nd ed., 1885, p. 162).

In a letter, Sir Archibald has obligingly stated that the first and best account on which the reference to the above was based is by Dr. C. Barrois, Ann. Soc. Géol. du Nord, vol. vi (1878–9), p. 366. See also his short paper in the Assoc. Française, 1879, p. 666. Gosselet quotes Barrois in his great work "L'Ardenne," 1888, p. 829. Further references are also given by these two authors.

1885. The Rev. A. Irving, taking it for granted that a large river in Eocene times flowed from a region of Palæozoic rocks in the west, in the direction of the Thames Valley to the east, said that the detritus would be quartzose and felspathic; the felspars would ultimately be decomposed by the agency of carbonic acid, and gelatinous hydrated silica would be produced. (Proc. Geol. Assoc., vol. viii, pp. 156, 157.)

1887. The Rev. A. Irving, in a letter dated March 6th, 1887, writes:—"You have overlooked one point which I have tried to bring out in some relief—the fact that the surface acquires a porcellanous texture, not due to cementation by iron (for from the superficial layer the iron is entirely leached out), but to an actual change of the material by a solution-process. I suggested (three or four years ago) CO_2 as the chief agent; but later work has shown me that the organic acids contained in *peaty* water have played a far more potent part in this sub-metamorphic change."

1888. In the Geological Magazine, Dec. III, Vol. V, Dr. T. G. Bonney states that the Sarsens of the Tertiaries are of concretionary origin: "In the Sarsen Stones, and with matrix of the Hertfordshire Puddingstones, there is chalcedonic silica converting sandstone into quartzite" (pp. 298–300).

1888. J. Prestwich: "Geology," etc., vol. ix, p. 342. "These sands [of the Woolwich and Reading Series] also occasionally contain concreted blocks in irregular local beds of sandstone, sometimes with very hard siliceous cement." Footnote at p. 342: "Mr. Whitaker and Prof. Rupert Jones think that in Berkshire and Wiltshire they [the Sarsens] are more frequently derived from the Bagshot Sands." The 'Puddingstone' of Bucks and Herts is here referred to the Reading Beds. Further on, at p. 364, it is stated that Sarsens occur in the Bagshot Sands of Frimley and Chobham.

N.B. — Concretionary action has produced in many Sarsens mammillations on a large scale, which show on some surfaces irregular, coalescent, smooth swellings, with shallow, valley-like slopes and depressions, like those on the so-called 'bowel-stones' of the Lower Greensand near Aylesbury. H. B. Woodward's "Geology of England and Wales," 2nd ed. (1887), p. 377. Such mammillated Sarsens occur in Suffolk, Wiltshire, and elsewhere.

N.B.—The convexity of the lower face of a Sarsen lying in its original sand-bed is due to the concretionary formation of the stone.

1901. J. W. Judd's "Note on the Structure of Sarsens" (Geol. Mag., January, 1901, pp. 1, 2) gives definite descriptions

of the intimate constitution of many Sarsens from authenticated localities.

N.B.—Besides the Tertiary sandstones, other and older white sandstones have yielded large and small blocks, now on the surface or in superficial deposits; for instance, Upper and Lower Greensand, Liassic sands, Millstone Grit, etc.

§ 2. Fossils.

(Refer also to pp. 142–147 of Part i in Wilts Mag., 1886.)

1871. Professor John Phillips, in his "Geology of Oxford," 1871, p. 447, states:—"I have never found shells in any of these stones lying in their native beds, and have some scruple in mentioning that they do occur in a layer in one of the blocks at Stonehenge. But, as I did not choose by chiselling that monumental stone to attract attention to it, probably it may for many years to come escape all injury except that which it must suffer from the strokes of time."

1878. In the churchyard of Sandhurst, a large Sarsen perforated with pipe-like holes lies at the foot of the old yew-tree there. (T. R. J., Trans. Newbury Distr. F. Club. vol. ii, p. 249.)

1887. C. C. King suggested that in the Avebury district the Sarsens were more particularly perforated by rootlets, and that, if so, the shoals or sandbanks formerly bearing the trees were better conditioned for the vegetation than other parts of the formation.

1888. J. Prestwich: "Geology," etc., vol. ii, p. 344. The indications in the Sarsens of the former presence of rootlets, possibly of Palms, are here mentioned.

1888. The same kind of fossil tubular marks in Sarsens may be seen in some blocks on the side of the Newbury-Hermitage road, or Long Lane, west of Coldash Common.

1897. Rootlet-holes, mostly vertical, occur in a Sarsen in a brick-field near Watford, Herts.—C. D. Sherborn.

N.B.—The perforations due to rootlets have been widened on the exposed surfaces of the stones by water-action and blown sand, so as to leave the surface variously pit-marked.—T. R. J.

N.B.—Analogous pipe-like remains of rootlets occur as long, small, vertical holes, in the Hastings sand-rock, East Cliff, Hastings (*Geologist*, vol. v, 1862, pp. 135, 136, fig. 9; and Geol. Mag., 1875, p. 589); in the Triassic (?) Sandstone of South Sweden; and in some of the estuarine, Jurassic shales of Yorkshire, near Whitby (A. C. Seward) and near Scarborough.—T. R. J.

§ 3. Localities.

I. (1) *Northamptonshire.*—1896. Mr. Edwin Sloper observed in a pit at the Northampton Brickworks at Blisworth a Sarsen that had evidently fallen from the base of the Drift overlying the Lias clay there. This Sarsen was to be cared for by being placed in the gardens of the Hotel at Blisworth. It consists of a white sandstone with siliceous cement, and with filamentous cavities, which are faintly stained with limonite.

(2) *Suffolk.*—1889. Sarsens are abundant in the neighbourhood of Nayland, at corners of cross-roads and elsewhere. Fine-grained

saccharoidal, and stained. Many with large and small tubular holes, some of which are split open and form furrows on the surfaces, often due to old natural splitting.

1889. Hartest Green, Suffolk. A large brownish Sarsen (5 ft. 8 ins. × 5 ft. 2 ins. × 3 ft. 6 ins.), much rounded (almost like a boulder), fine-grained and whitish inside, where wounded by blows of stones. Much pitted naturally on the outside. Flattened at the top, and worn smooth by boys' play. It was taken years ago out of a field now occupied by Mr. Griggs, and required eight horses to drag it. It is stated in a letter from a resident there that "it measures 12 feet round (probably touching the ground for 6 feet of its length), and about 4 feet across, weighing 5 or 6 tons." It is not alluded to as a boulder by the Committee on Boulders, etc. (British Association).

1889. At Newton Green there is a large Sarsen stone ($4\frac{1}{2} \times 3 \times 2$ feet) by the side of the pond next to the "Saracen's Head" Inn, which shows on one side a 'bowelly' surface, and the other sides split flat.

1889. One stone (3 feet long) with bowelly surface, and with tubules, is at Frost Farm, Stoke, near Nayland. Near Nayland, at the corner of cross-road from Bures to Colchester, there is a Sarsen 7 ft. 6 in. long, roughly oval in outline. By the side of the high road near the Popsey bridge, a little east of the Anchor bridge, Nayland, a Sarsen standing on the bank ($3 \times 1\frac{1}{2}$ feet) shows a natural surface with a large hole, also a boldly mammillated surface (bowelly). Its upper end and sides are split flat; lower end buried.

1889. In a letter dated Ipswich, September 12th, 1889, the late Dr. J. E. Taylor obligingly informed me, with regard to some Sarsen stones found at Ipswich, that "the Reading stone-bed specimen [not a Sarsen] is highly calcareous, but I have found no traces of Foraminifera in it. The mammillated stone is purely siliceous. . . . . The siliceous stones are abundant hereabouts; the others not so. I got them both [the stones referred to] during the excavation of the deep sewers in one of the streets of this town."

(3) *Essex.*—1896. T. V. Holmes: Proc. Geol. Assoc., vol. xiv, p. 190. A large Sarsen is here mentioned that has been removed from the Glacial Gravel at Writtle Wick, near Chelmsford. A note on the possible origin of the word Sarsen is also given.

1896. A. E. Salter: Proc. Geol. Assoc., vol. xiv, p. 394. In the Epping Forest gravel A. E. Salter noticed "Sandstones and Sarsens, both large, various, and plentiful. At Epping Forest I saw three, measuring 9 in. by 5 in., 12 in. by 6 in., and 20 in. by 5 in. respectively." In the high-level Glacial Gravel at Witherthorn, four miles east of Ongar, "large Sarsens (2 ft. by $1\frac{1}{2}$ ft.)" (p. 395). At Woodton, in the Yare Valley, "a block of Hertfordshire Puddingstone was found" (p. 399).

(4) *Hertfordshire.*—1897 and 1899. The Rev. Alex. Irving describes both Sarsens and Herts Puddingstones as common in the Stort Valley (Herts and Essex). He refers both to the Bagshot Series, the latter particularly to the Pebble-beds; and he states that both rocks are agglutinated by the same kind of siliceous cement

(Proc. Geol. Assoc., vol. xv, pp. 196 and 236). He duly mentions that Mr. Whitaker regards the Hertfordshire Puddingstone of the neighbourhood under notice as having, in part at least, been consolidated pebble-beds of the Woolwich and Reading Series, like those at Addington, near Croydon. See also Mr. Whitaker's Address to the Herts Nat. Hist. Soc., Proc., vol. x, pt. 4 (September, 1899), p. 116.

(5) *Buckinghamshire.*—1890. A row of coarse, gravelly Sarsens lies along the side of the road up to the church at Badenham. They were placed there by the Rector, who said that such stone underlies the Rectory house and lawn close by; and some blocks of it were still lying about there. In the church tower, up along the re-entrant angles of the buttresses and tower, numerous ordinary fine-grained Sarsens are built in with the flint-work. Professor Prestwich said, June 21st, 1890, that the coarse-grained Sarsens at Bradenham came from the base of the Tertiaries.

In Buckinghamshire Sarsens are known as 'Wycombe stones,' and in the Bagshot district as 'Heath stones.'

(6) *Oxfordshire.*—1871. Professor J. Phillips regarded the Sarsen stones as concretionary portions of extensive sand-beds once overlying the district with its previously excavated Chalk valleys. The loose sands were carried away by denudation, and the solid portions suffered displacement. Some containing flint pebbles and fragments lie on the north side of the Wiltshire downs. Some large Sarsens are found in the Drift, for instance at Long Wittenham, near Abingdon. See his "Geology of Oxford and the Valley of the Thames," 1871, pp. 447 and 462.

(7) *Middlesex.*—1891. Horace B. Woodward, in the Geol. Mag., Dec. III, Vol. VIII, pp. 119–121, succinctly described a very large Greywether, of irregularly quadrangular form, that was found lying in the London Clay, at the bottom of the Thames Valley Gravel, at Moscow Road, Bayswater, in enlarging the cellarage of the "King's Head." It was 9 ft. 6 ins. long, and at least 2 ft. 8 ins. thick. Mr. H. B. Woodward remarks that Sarsens have been found in many places at the same horizon in the base of the Thames Valley Gravel—at the Law Courts in the Strand, and near Kew Bridge; at Ealing in the Brent Valley; at Ilford, and at Grays; but not usually of large size nor common. He notes also that Sarsens and Hertfordshire Puddingstone occur in the Brickearth in Buckinghamshire, derived in Glacial times from the wreck of Woolwich Beds and Bagshot Sands. The Thames Valley got its gravel mainly from the Glacial Drift. The Bayswater Sarsen is six miles distant from nearest known Glacial Drift; and, he says, "it is quite possible that this particular block may have been derived directly from an outlier of Bagshot Sands, or it may have been left as a relic of Preglacial denudation near the spot where it has now been found."

1895. At the Grove, Stanmore (the residence of Mrs. Brightwen), large Sarsens have been collected from the neighbourhood and made into a grotto. One slab measures about 6 × 3 × 2 feet; another,

about 6 × 6 × 2 feet. The surfaces of these two large slabs have been deeply scored by running water, and pierced in all directions by rootlet and other holes.—C. D. S.

1896. In the Proc. Geol. Assoc., vol. xiv, p. 158, Mr. Allen Brown states that "a large tabular water-worn Sarsen, and a portion of it broken off in Quaternary times," were found in the gravel at Hanwell; and that another Sarsen occurred at the base of the gravel at the back of Hanwell Station.

1900. In "The Pits," old gravel workings, an allotment, now wooded, belonging to William Sherborn, Esq., and formerly part of Bedford Common, Middlesex, there is a large Sarsen, measuring about 5 × 5 × 2 feet, from one end of which a block about a foot thick was removed.—C. D. S.

1900. In front of the roadside inn (the "Griffin") at Totteridge or Whetstone, near Highgate, stands a short thick Sarsen, about 25 inches high above ground, and 20 inches broad at top and 18 inches below. It is locally said to be as large again below the surface; and to have been used as a 'whetstone' for their weapons by the soldiers going to the Battle of Barnet (1471).—A. O. Brown.

1900. Horace B. Woodward describes a Greywether from the Gravel of South Kensington, in the Geol. Mag., December, 1900, p. 543 (with figure). It measures 3 ft. 10 ins. × 3 ft. 3 ins. × 2 ft., and is in many respects analogous to the specimen from Bayswater described above. A smaller one has just been found on the same spot (January 23, 1901).

(*To be continued.*)

IV.—Some Geological Notes on Central France.

By M. S. Johnston.

(PLATES II–IV.)

I THOUGHT, perhaps, some readers of the Geological Magazine might be interested in a few notes taken during the International Geological Congress excursion to the Massif of Central France and the region of the Causses, and on the chief rocks there, with the best places for finding examples.

By making Clermont Ferrand a starting-point, the Puy de Dôme may be visited first. The road winds its way up from the extensive plain of Limagne. This plain, of Tertiary age, extends all along the foot of the Monts Dômes from Brioude to the Loire. It is formed by an alluvial deposit left by an ancient lake of the age of the Paris Basin, whose waters at periods of high level probably flowed into Lac Limagne. The Monts Dômes rise abruptly from this plain, their basalt flows forming in places precipitous cliffs.

At Royat, the great basalt flow of Quaternary age is reached, at the foot of which abundant mineral springs gush out. On either side of the lava rise rounded hills of granite; the typical granite of these hills is grey and coarsely crystalline.

The Puy de Dôme is composed of trachyte. The typical rock contains large crystals of sanidine, and is very acid, having 62 per cent. of silica. M. Michel-Lévy is of opinion that the trachyte is

a dyke which has been buried in the scoria, projected from the crater, of which every vestige has been obliterated. On the north side of the Puy de Dôme there is a curious sandy scoriaceous deposit, containing small rounded grains and specular iron. The grains are considered by M. Michel-Lévy to be lapilli from the volcano. Down the side of the Nid de Poule there is a large deposit of scoria and bombs of various forms.

The Puy de Pariou is a scoriaceous cone, with an immense lava stream of andesite flowing round the eastern side of the cone to the basaltic plateau of Prudelles, which imposed so great a barrier that the stream divided and flowed down to the Limagne plain on either side of the plateau. Between Puy de Pariou and Prudelles, at Le Cressigny, a cordierite gneiss may be found, while the Pliocene basalt of Prudelles contains zeolites.

Proceeding from Royat by train to La Bourboule, the confines of Mont Dore massif are entered upon. The line runs round the north of the Monts Dômes. At Volvic a fine andesitic stream is crossed; this stone is much quarried for building purposes, whose durable qualities are well seen in the cathedral of Clermont Ferrand.

On arriving at La Bourboule, the first section of interest is at a short distance from the station at Lusclade, where rhyolites, perlites, phonolites, and trachytes are found. One section of rhyolite, facing the road to Mont Dore and at a small gorge, shows remarkable stratification, the rhyolite being of two kinds, glassy and fibrous. Up the gorge the rhyolite becomes perlitic, and masses of ophitic basalt from the heights above have fallen into the bed of the stream. Phonolites without nepheline, with nosean and haüyne, are found a few yards further to the south.

The district of Mont Dore is formed by two principal centres of eruption—one at the Pic de Sancy, the other between the Banne d'Ordenche, Puy de la Croix Morand, and Puy de l'Angle, overlooking the gorge mentioned above. The Pic de Sancy is trachytic, and fine porphyroidal trachyte may be found on its northern slopes. In the ravines of the Grande Cascade and Egravat remarkable sections are seen, tuffs and conglomerates of trachyte or andesite alternating with compact flows of different rocks, as trachytes, andesites, basalts, and labradorites.[1] The greater part of the massif is formed of materials of every size from fine cinerites to conglomerates.

Cinerites containing vegetable remains are well exposed on the west side of the valley of the Dore, to the north-west of Mont Dore les bains. At the Ravin de la Grande Scierie is an interesting example of denudation and successive volcanic phenomena. The bottom of the ravine is of cinerite, which rises on either side and is capped by porphyritic trachyte. After the first erosion of the valley a stream of lava poured down it, partly filling it, and which was in its turn eroded and has left its mark in a bank of andesite on both sides of the ravine. A little further on is a basaltic dyke rising

[1] A labradorite of French geologists is a basic andesite of English geologists.

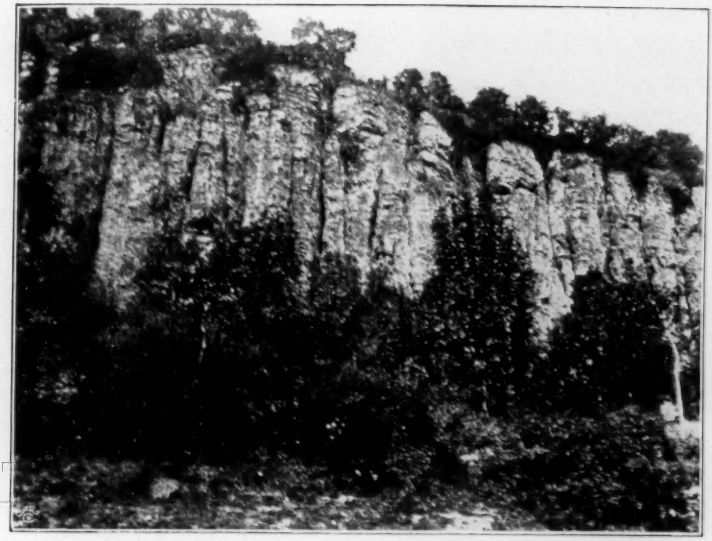

FIG. 1.—The Orgues de Bort, left bank of the Dordogne.

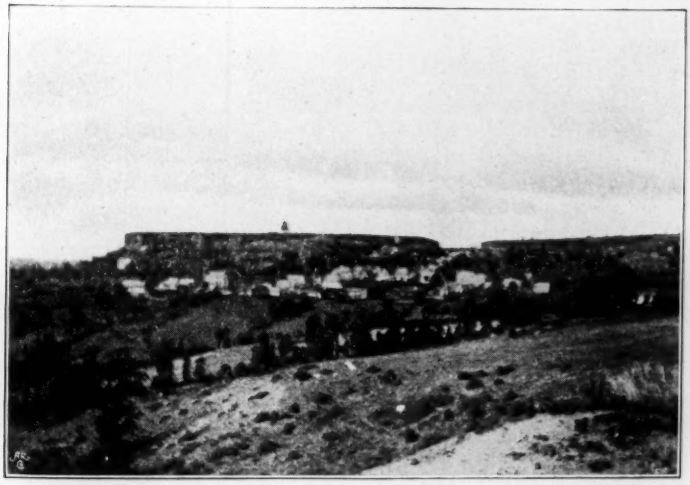

FIG. 2.—Promontory of Basalt, Carlat.

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as an isolated hill in the centre of a circular valley. This is the Roche Vendeix.

After traversing some woods the road opens on to a fine panorama, an immense circle bounded by the mountains of Mont Dore, the Cantal and Cézallier, and the hills of lesser heights, the Orgues de Bort and the Limousin. The village of Latour is built on a basaltic promontory. The columns of basalt are magnificent; their broad tops serve as excellent foundations to the houses, and are especially well seen in the small hill, on which once stood a castle.

Here the road descends into the valley, and the scenery is changed. Rounded and striated hills of granite betoken the presence of ancient glaciers, and between them stretch marshy fields of peat, whose undersoil is formed of scratched pebbles and erratic blocks of every size. The glaciers were of Pliocene age and when the volcanoes of Auvergne were at their highest. The glaciers have scooped out curiously shaped valleys, and the moraines lie along successive hills, whose contours are rounded and lowered as far as La Pradelle, when the materials spread themselves out over a flat tableland, which constitutes the plateau of Lanobre and extends to the Orgues de Bort, whose precipitous escarpment dominates the left bank of the Dordogne. It may be added that at Bagnols erratic blocks, forming immense heaps, repose on rounded, polished, or striated cordierite gneiss.

From Bort a short drive brings one up to the Orgues de Bort; these 'orgues' are of phonolite (Pl. II, Fig. 1). A cap of phonolite, rising in immense columns, overspreads a hill of augen gneiss. Many of the 'eyes' in this gneiss are very large and in regular and continuous layers.

The view from this hill is very fine. The massifs of Mont Dore and the Cantal are both seen; the Dordogne and the Rhue have cut narrow precipitous valleys on the north and east, but on the south, after the junction of the two streams, the valley widens and there are some small glacier-formed lakes, which are filling with peat.

On leaving Bort by train for Aurillac the line, a marvel of engineering skill, winds between the spurs of the Cantal, which the train crosses, ascends, and descends in constant succession. Before reaching the slopes of the Cantal a small Carboniferous deposit is crossed, in which mines are worked at Champagnac.

Aurillac is built on the banks of the Jordanne, and on crossing the railway to the south of the town the alluvial terraces of Quaternary age, with the rounded hills of mica-schist rising above them, are very noticeable. There is also in this valley other evidences of glacial action, and at Vezac a Quaternary moraine is prominent, forming waterfalls and rapids in the small stream.

The next interesting section on the road to Carlat is an andesitic conglomerate at Cabanes. This conglomerate is found in great blocks amongst tuffs and andesitic dust, and forming a high hill. The theory concerning this deposit is, that it may be the projection of what was the last effort of the volcano. From this hill is also seen a wonderful promontory of basalt. This promontory is formed

of very regular columns and overlies a Pliocene river bed, situated some hundred feet above the valley of the Goul. The basalt is breached in places; the largest, as seen in Pl. II, Fig. 2, has caused the andesitic breccia below to be seen.

After leaving Carlat the road takes a sharp turn to the south, and a section of cinerite, with loose felspar crystals, is found near the top of a hill overlain by concretionary Miocene sand.

The road now continues around the southern spurs of the Cantal, which presents new vistas of beauty at every turn, and on reaching Curebourse a magnificent panorama of the valley of the Cére is obtained. At a short distance from Curebourse and above Vic-sur-Cére is the celebrated section of Mougudo of compact cinerite, containing fossil plants. About twenty-two species of plants have been found there, in the shape of leaves, twigs, trunks, and wood opal.

The road now follows the valley of the Cére, where there is an abundance of volcanic breccia, mostly capped by columns of basalt. At Thiezac, near St. Jacut, is a noticeable section across the valley and one which may be easily distinguished at sight. On the north-west side the highest rocks are of andesite, then a band of porphyritic basalt, beneath this a mass of breccia, with dykes of andesite and labradorite overlying the mica-schists. The formation of the small hill, on which stands a white statue of the Virgin, is a dyked breccia, while on the south-east side of the Cére rises a dome of trachyte and phonolite, tilting the breccia containing andesite and cinerite dykes, and capped by andesite and Oligocene basalt.

The two most striking features now in the landscape are the peak of the Puy Grion, a weathered phonolite dyke on the left, and the Plomb du Cantal, the highest summit in this region, and situated on the edge of the crater ring on the right. The lateral ravines and the flanks of the cirques are riddled with dykes, as are also the cliffs along the valley of the Allagnon, which is reached by the tunnel of Lioran, three-quarters of a mile long.

At a waterfall not far from Lioran a trachyte called the 'roche de deuil' is to be found, and at Laveissière, a short distance further on, the base of an ancient volcano may be seen resting on Oligocene limestone. The Rocher de Bonnevie rises in successive tiers of basaltic columns above the town of Murat, and there is also a fine example of columns, showing various directions of contact cooling in the hill below Brédon church. In the village of Brédon are cave dwellings, which were inhabited as late as fifteen years ago.

From Murat a good excursion can be made to the Puy Mary (Pl. III, Fig. 3). The road leads up the valley of the Chevade to the Col d'Entremont, where there is a large exposure of augitic andesite, with haüyne, which is used for tiles. Many of the specimens are good sounding clinkstones. At this point the road descends and crosses the valley of the Dienne, which has its origin at the foot of the Puy Mary, and is a good example of a glacially and aerially denuded valley.

FIG. 3.—Puy Mary and the Valley of the Dienne.

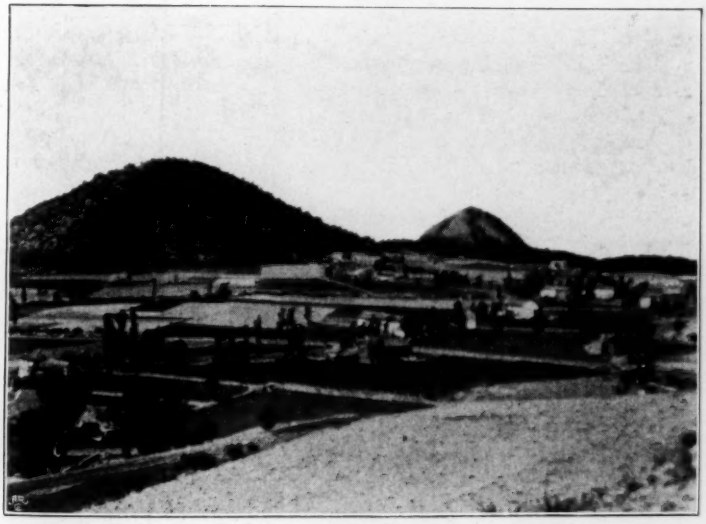

FIG. 4.—Phonolite Hills in the Megal, Velay.

The peak of the Puy Mary is capped by an andesite, with porphyritic felspars and hornblende, overlying a band of porphyroidal basalt, which is situated on a mass of breccia; the whole three deposits being dyked by phonolite, basalt, and andesite. From the top of this Puy a fine view of the crater of the Cantal is obtained. The Cantal massif was formed by one crater, the remains of which may be traced from the Puy Mary; its ring is eight miles in diameter, the highest points being the Plomb de Cantal, the Puy Mary, and the Puy Chavaroche. In the centre of the crater are several cone-shaped hills of phonolite, the Puy Grion being the highest. These are weathered dykes, phonolite having the peculiarity of weathering into cones, as will be observed in Pl. III, Fig. 4 of the phonolite hills of the Megal district.

The order of deposition in the Cantal region is—Miocene basalt, trachyte, and phonolite; andesitic breccia; andesitic and phonolitic flows; and finally, the plateau basalt.

On leaving the Cantal district and proceeding by train to Le Puy, another volcanic area may be studied, that of Velay. The chief points to be noticed along the line are the union of Quaternary moraines from the valleys of the Allagnon and Allange at Neussargues, and at Merdogne a remarkable basaltic rock overspreading cinerites, containing Miocene flora; at this point also the valley casts off its glacial character, and narrows itself between walls of gneiss, often amphibolic. At Lempdes the plain of the Limagne is reached, but soon the line turns to the south, and after Arvant it passes over some part of the Oligocene plain and then on to the gneiss again. At Darsac is to be seen a characteristic view of the plains of basalt, with the scoriaceous cones of the axis of the Velay chain in the distance.

The plain in which Le Puy is situated bears striking evidence of the wearing away of volcanoes. In the centre are two isolated rocks of breccia, the Roches Corneille and Aguilhac, surrounded by Oligocene deposits. From the Roche Corneille is seen the plain, whose edges rise on all sides in terraces and hills, first of ravined Oligocene deposits, then of volcanic remains. Over the hills to the south and east are the Mezen and Megal peaks. On the north, in the middle distance, is a small volcano which has been cut in half; the crater pipe and outer slopes can still be clearly traced. The hills of Polignac and Denise are both of interest. At Denise the hill is composed of a pipe of scoria, often containing granite, and two varieties of breccia, one of Middle Pliocene age, the other of the age of *Elephas meridionalis*: in the latter was found the 'Man of Denise,' but how he got there is still a vexed question; his skeleton has been placed in the Le Puy Museum.

The Loire flows along to the east of Le Puy, but in early Quaternary times the principal river flowed away to the west on the south of the town.

The Megal and Mezen district is one of the most interesting round Le Puy. This region is the oldest volcanic area of the Velay, and is composed almost entirely of basalt and phonolite; indeed, the

latter is so abundant that it is called 'le pays des phonolites,' and the rock gives a characteristic appearance to the landscape (Pl. III, Fig. 4). Some of the best sections for obtaining it are at Lardeyrol, specimens without nepheline; at Mont Pidgier, containing a vast quantity; at Boussoulet and Montvert, a phonolite rich in nepheline and ægyrine; near Estables the 'rocher d'Aiglet'; and the Mezen peak itself is mainly composed of this rock.

On the road from Le Puy to Blavozy are several excellent sections of arkose of Eocene age and Oligocene sandy clays and spotted marls, while at Blavozy itself there is a very large deposit of arkose, in which great crystals of orthoclase from the older granite appear. At Queyrières is found a good Miocene trachyte.

There are a few glacial lakes in this district, the chief one being that of St. Front, crater-form in shape and worn in the basalt.

Large crystals of orthoclase and hornblende can be picked up in the labradorite tuffs of Besseyre, many of the hornblende crystals being very nearly perfect in shape. Between Coubon and Le Puy may be noticed the lava streams from the Mont Jonet of Quaternary age, overspreading those of the Garde d'Ours, which was an active volcano in Pliocene times.

The geologist may now, if he chooses, pass from the land formed by the internal fires to that deposited in the waters, by driving from Le Puy to Mende, a distance of ninety-two kilometres. One first traverses igneous and metamorphic rocks as far as Mont Lozère, at which point the Liassic and Jurassic plateaux are reached, and where the road makes a rapid descent into the valley to Mende.

The rocks to be noted *en route* are first the bombs containing peridotite found in a cone at Tarreyre. Basaltic plateaux are crossed until one arrives at Langogne. The hills on the west side of the valley of the Allier are of porphyritic granite; here the felspathic crystals of orthoclase are very large.

From Chateauneuf de Randon one perceives the Causses, of Secondary age, rising against the crystalline mass of Mont Lozère. The Causses are immense undulating barren plateaux of limestone of Jurassic age. There are frequent depressions called 'sink-holes,' and the whole country from Mende to the Cevennes on the south is supposed to be riddled with caverns; some with underground streams, as at Bramabiau and Padirac, others, where there is an entire absence of running water and where they are slowly filling with stalactitic materials, as at Dargilan.

Pl. IV, Fig. 5 is a view taken from the pathway up to Dargilan, the entrance of the cave being at the top of the cliffs in Middle Jurassic dolomitic limestone; the rounded formation on the top of the precipitous cliff is of Kellaway age. The Causses are also cut up by cañons, that of the Gorge de Tarn being the largest. The river of this gorge is fed by underground springs, and its sides are weathered out into pinnacles and buttresses.

In the Dourbie gorge, not far from Milhau, is Montpellier-le-Vieux. The limestone on the top of the Causse Noir has been worn away either by weathering or, as some think, by underground

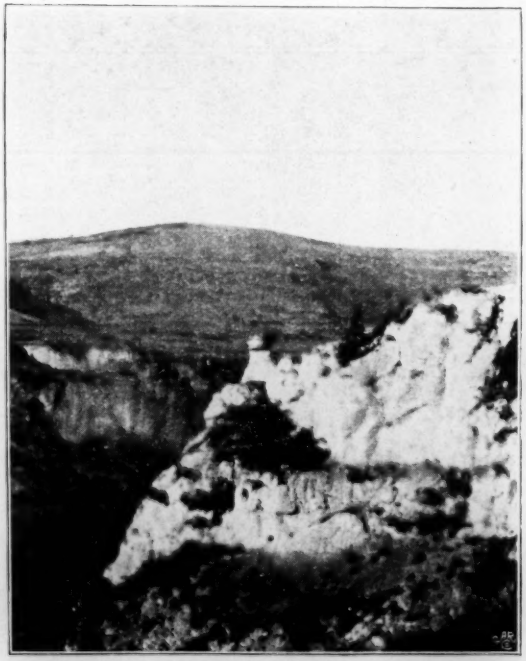

FIG. 5.—Below the Cave of Dargilan, Middle Jurassic Limestone.

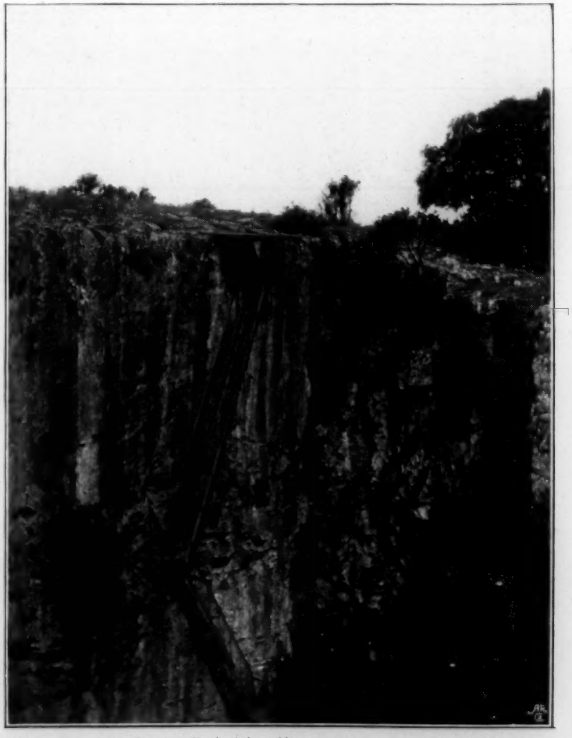

FIG. 6.—Tindoul 'Puit,' leading to the underground river near Rodez.

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streams and afterwards aerial denudation. Here is the most wonderful representation of an old city, with its ramparts, castles, and halls; there are, of course, many fantastically sculptured rocks, but the Chateau Gailliard is a marvel, of which only the eye can form any idea.

At Eglazine, in the Tarn gorge, is a basalt flow which has half filled a denuded volcanic neck of breccia. In the basalt, which is Pliocene in age, are large crystals of augite and inclusions of olivine. The breccia also contains well-developed crystals of various minerals.

The Tindoul (near Rodez) and Padirac (near Rocamadour) caverns have very deep holes or 'puits' to the entrance of the underground galleries. The one at Padirac is 245 feet; the Tindoul is a little less (Pl. IV, Fig. 6).

The Bramabiau is situated near the east and west fault which brings up the crystalline rocks of the Cevennes above those of Jurassic age. This fault is very well marked by the configuration of the country, as to the north of it are the table-like causses, to the south rises the jagged outline of the Cevennes. The Cevennes are the watershed of the Mediterranean and the ocean rivers, and their south-east and north-west slopes present different aspects. From Mont Aigoual, on the south and east, are seen narrow and steep gorges in endless successions; the spurs of the mountains, running out in long rows, give the appearance of waves of the sea. On the north and west the valleys are broader and less steep, and the mountains have flatter tops.

Mont Aigoual is formed by a granite intruded into the Cambrian sandstone, which has been metamorphosed into gneiss and schists. The granite is porphyritic, containing large orthoclase crystals, sometimes four or five inches long.

An excursion to these parts may be ended at Rocamadour, a curious little village clinging to the precipitous side of a cañon and celebrated during many centuries for its pilgrimages.

V.—On an Insect from the Coal-measures of South Wales.

By H. A. Allen, F.G.S.

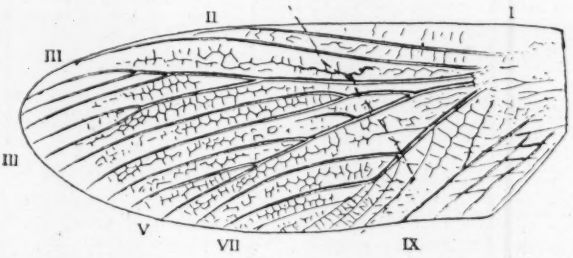
THE rarity of insect remains from the Carboniferous rocks of the British Isles is demonstrated by the small number of genera and species included in the lists published by such authorities as Dr. Henry Woodward[1] and Mr. S. H. Scudder.[2] A portion of a wing, with a neuration unlike that of any specimen yet described, having recently been exhumed, it may be deemed not unworthy of notice.

The specimen was obtained by Mr. G. Roblings from the top of the four-foot seam in the Lower Coal-measures of Llanbradach Colliery, Cardiff. A fragment of shale split into two pieces exposes nearly the whole of a wing lying almost flat; the distal portion of

[1] Quart. Journ. Geol. Soc., vol. xxxii (1876), p. 63. Geol. Mag., 1887, p. 49, Pl. II; ibid., p. 433, Pl. XII.

[2] Mem. Boston Soc. Nat. Hist., vol. iii (1883), pp. 213–224.

it, as far as the broken line in the figure, is seen on one half of the shale, and a little more of the basal part on the other. The base is wanting, and what remains of the basal portion has suffered much injury. The length of the fragment, measured from the apex, is 41 mm., and the greatest breadth of the wing, measured from the costal to the posterior margin, is 13 mm.



Wing of *Fouquea cambrensis*, n.sp., from the Coal-measures of South Wales. × 2.

The costal nervure (the *vena marginalis* of Heer), numbered I in the Figure, is marginal.

The subcostal (*v. mediastina*), II, is simple, and is situated about midway between the costal and the anterior branch of the radius. It curves gently towards the costal margin, and dies out at about 12 mm. from the apex of the wing.

The radius (*v. scapularis*), III, is bifurcated near the base; its anterior portion is simple, curves gently towards the costal margin, then turns rearward, and dies out near the apex of the wing. The posterior portion of the radius is situated slightly in advance of the long axis of the wing, and runs nearly in a straight line towards the apex. It gives off a bifurcated branch at 15 mm., a simple one at 10 mm., and a second simple branch at 8 mm. from the apex of the wing. All these branches of the posterior portion of the radius reach the posterior margin of the wing near the apex.

The median (*v. externo-media*), V, is forked at a short distance from the base; the anterior branch runs parallel with the radius for a distance of 6 mm., and then divides into two minor branches, which reach the posterior margin by a slight curve. The posterior branch of the median runs straight towards the margin, produces a few branchlets, and, 9 mm. from its point of bifurcation, sends an offshoot direct to the margin; 4 mm. further the branch bifurcates. All the branches of the median join the apical half of the posterior margin.

The cubitus (*v. interno-media*), VII, is directed towards the middle of the posterior margin until within a distance of 2 mm., where it turns sharply in the direction of the apex. A simple branch is given off at 5 mm. from the margin, and a few branchlets may be seen running out from the main branch.

Nearer the base faint indications of nervures occur which may form the anal system (*v. analis*), IX, but, on account of the injured condition of the wing, their origin cannot be traced.

Over the areas between the principal nervures there is a delicate reticulation. No transverse nervules are present, with the exception of a few faint traces in the costal area. The specimen assumes the colour of the shale in which it is embedded.

Of the few wings known from the British Carboniferous rocks, those of *Lithomantis carbonaria*, from the Coal-measures of Scotland, described by Dr. H. Woodward,[1] to a certain extent resemble our specimen, but differ in the shape of the area situated anteriorly to the subcostal nervure, i.e. the costal area, which in *L. carbonaria* is narrow near the base and increases in width towards the apex, whilst in our specimen the reverse obtains. The difference in the shape of the wing and in the neuration will not admit of the specimen above figured being referred to *L. carbonaria*, H. Woodw.

For corresponding reasons this new specimen cannot be placed with *Lithomantis Goldenbergi*, Ch. Brongn.,[2] notwithstanding the fact that the costal area is somewhat similar in shape. The posterior or branched limb of the radius is situated much further from the anterior margin than in either of the two species of *Lithomantis* mentioned, and bears fewer branches.

Gryllacris (*Corydalis*) *Brongniarti*, Mant., from Coalbrookdale, differs from the South Wales specimen in its neuration, especially in the radius, which bifurcates much nearer the apex of the wing, and also in the transverse nervules, which are strongly marked.

In the simplicity and general appearance of its neuration our wing much resembles *Dictyoneura sinuosa*, Kliver,[3] but in that species the important subcostal nervure is directed towards the apex and does not curve towards the costal margin. M. Kliver's specimen lacks both base and apex, and therefore the above-mentioned character may perhaps be deceptive.

The genus *Fouquea*, to which our specimen may be referred, is described by Ch. Brongniart,[4] who states that "it agrees with *Lithomantis* in its neuration, but differs greatly in the reticulation; the nervules which unite the nervures are so numerous that they anastomose and form a veritable network."

The shape of the wing, the position of the longitudinal nervures, and the reticulation in our specimen bear a general resemblance to *Fouquea Lacroixi*, from Commentry, but neither of the two species figured by C. Brongniart[5] exactly agree with it, since in both of them the branches running from the principal nervures to the posterior margin are more numerous. The cubitus also shows a considerable difference.

The specimen differs from any described form that has come under my notice, more especially in the cubitus. The injury to the base of the wing is most unfortunate, and it is consequently impossible

[1] Quart. Journ. Geol. Soc., vol. xxxii (1876), p. 60, pl. ix, fig. 1.
[2] Rech. Insects Fossiles, pl. xxxvii, figs. 1, 2.
[3] Palæontographica, Bd. xxix (1883), p. 260, t. ii, fig. 4.
[4] "Rech. Insectes fossiles des Temps prim.," p. 372; St. Etienne, 1893.
[5] Op. cit., pl. xxxv, figs. 10, 11.

to trace any of the principal nervures to their source, but the wing is otherwise in a good state of preservation.

It will be placed, provisionally, in the genus *Fouquea*, Ch. Brongn., and, in order to note the principality in which the wing was found, I propose the name *Fouquea cambrensis*.

The specimen has been presented to the Geological Survey Museum, London, by Mr. Roblings.

VI.—Recent Denudation in Nant Ffrancon, North Wales.

By Edward Greenly, F.G.S.

READERS of this Magazine may remember that early last August there were descriptions in many provincial and even in some London newspapers of an extensive 'landslip,' which had occurred on the side of the mountain called Carnedd Dafydd, on the eastern side of the valley of Nant Ffrancon, in North Wales. The impression conveyed was perhaps somewhat exaggerated, and yet the phenomenon was on a scale quite large enough to be of geological importance.

In a brief but vividly written article in the Geological Magazine for January, 1900, my friend Mr. J. R. Dakyns described a number of cases of denudation on an important scale that had come under his observation. It may be well, therefore, in the same way, and under a similar title, to preserve a record of this landslip. There was almost incessant rain from the 5th to the 10th of August, with streams all in heavy spate and floods in many districts, and on August 6th (I believe) at about 4 p.m. two torrents broke out on the side of Carnedd Dafydd, carrying with them a great deal of debris, and blocking the road in the valley for many yards. The spot is on the eastern side of the valley, nearly opposite the house called Pentre, shown on the Geological Survey and old Ordnance Maps.

The mountain side here is composed of the Bala volcanic series, alternations of various igneous rocks with hard grits, resting, with a south-easterly dip, upon a thick mass of softer and rather homogeneous black slates. The volcanic series form a great range of crags along the brow of the mountain some hundreds of feet in height, cut into huge buttresses and deep recesses, while the dark slates give rise to long uniform steep slopes extending from the foot of these crags to the bottom of the valley, and along them the road is carried at a height at this point of about 200 feet above the alluvial plain. These slopes are covered with great sheets of scree, resting upon loose glacial debris, which, though rising here and there into moraine-like mounds, have for the most part, and at the point where the landslip occurred, a pretty uniform slope.

As we pass up the valley from the north we see nothing but two streams of stones, grey and fresh-looking, near the road. They do not extend far up the slopes, and appear, indeed, rather insignificant; but this is due to the great depth of the valley, and when we arrive at the place where they cross the road they are much more imposing in appearance. From this point we see that they are fans of debris spread out at the ends of two long channels, which, light grey and evidently quite newly cut, are conspicuous features all down the

slopes from the foot of the crags. The northern one can be traced by the eye a little way up into the crags themselves, but from below we cannot tell whether the two channels, which disappear behind a great rocky buttress, have or have not a common origin.

The northern stream of debris crossed the road, broke down the wall, and poured over on the other side a fan or cone of great stones all the way down to the alluvial plain, while the finer material was spread out upon the alluvium itself, and some even reached as far as the river Ogwen. This fan is about 58 yards wide at the road, and begins a considerable distance above it, the angle at its top being a moderate one.

Some of the debris is very coarse. I measured one block of felsite 12 × 6 × 4 feet, standing on its narrow side, a little way above the road. How far this had been carried by the torrent, I do not know; it may have been embedded in the drift before, but from its position on the fan it must have travelled a good many yards.

The southern stream crosses the road about 175 yards further on, and is about 33 yards wide at that place. It is more conspicuous in the distance than the other, and the amount of material at the road is very great, but it does not go so far down into the valley, the debris stopping on the steep slopes and not reaching the alluvium.

Above these fans the work has been wholly erosive. At the head of the northern one the channel cut in the drift and scree seemed to me to be more than 20 feet deep, and I think that it was cut down to the solid slate here and there. On the steep rocky slopes at the crag's foot the gully had been swept very clean and white. Whether the erosive work affected solid rock as well as drift, I cannot tell. I saw no sign of a rock-fall in the crags, and to ascertain whether there was any it would be necessary to go some way up into the gully. The material of the fan, however, did not seem to me quite angular enough to suggest any great fall of solid rock, considering the short distance of transport.

Whether this be so or not, it is clear that torrential denudation, the work of only one afternoon, and probably of a very short time in that afternoon, has cut channels through 20 feet or more of drift and scree on the mountain side, moved blocks of felsite of as much as 288 cubic feet, and spread out fans of stones and debris a quarter of a mile in length.

The fans and channel would be well worth being photographed. In the *Windsor Magazine* of November last there is an account of a disaster near Driffield in the Chalk wolds of Yorkshire, said to have been caused by a 'waterspout.' The article is illustrated by photographs, not only of damage to buildings, but of channels and fans of debris very like these; and the point of origin is there quite clear. These views, indeed, are of considerable geological interest.

In view of the great importance of the subject of denudation, it really seems a pity that instead of occasional papers, there should not be some kind of regular organization for collecting and recording descriptions of what is actually going on at the present time.

VII.—Alleged Prints of Echinoderms in Triassic Reptiliferous Sandstones.

By F. A. Bather, M.A., D.Sc., F.G.S.

In the Geological Magazine for January, 1901 (n.s., Dec. IV, Vol. VIII, pp. 3, 4), Professor Burckhardt describes certain markings in the sandstone matrix of specimens of *Hyperodapedon* and *Rhynchosaurus* in the British Museum, from Elgin, Shropshire, and Warwickshire (the last, however, not being, as implied by the legend to the figure, represented in the Museum). He believes that these are hollow imprints "left by Echinoderms of a Euryalid shape, having peripheral arms, either simple or forked," but he appeals to specialists to decide to which group of Echinoderms they are due. Since these marks are said to be exceedingly numerous, and since Dr. Burckhardt uses them as evidence of contemporaneity, I thought it my duty, as the specialist nearest at hand, to examine these statements without delay.

Any student of Echinoderms would probably gather from Professor Burckhardt's description that the impressions were those of Pentacrinid columnals, with a pentagonal lumen, and with occasional cirri. The outlines drawn by Dr. Burckhardt do not really agree with that of the disc of a Euryalid ophiuran, nor does the paucity of alleged arm-structures confirm that suggestion. The asserted abundance of the pentagons also favours the idea that they are due to Crinoid columnals, for many sandstones filled with imprints of those structures are known from all parts of the world and all ages, including the Trias. The only difficulty that a reader would find in accepting this conclusion would be, that these immensely numerous and by no means minute appearances have escaped the notice of all the eminent geologists and palæontologists who have devoted to these sandstones the most anxious and pertinacious scrutiny.

Examination of the actual specimens, in which I received the kind help of Dr. A. Smith Woodward, has led to very different results. In common with those of my colleagues whom Professor Burckhardt endeavoured to convince, I am absolutely unable to distinguish the appearances described and drawn by him. Anyone that looks long enough at a rough sandstone surface can make out as many patterns as there are faces in the fire. But a scientific question is not to be decided by the vote of a majority, and the fact that we cannot see may only show that our senses are deficient. Fortunately there is other evidence.

Professor Burckhardt himself adduces the "hollows left by Elgin reptiles" in favour of his interpretation. But these hollows are all quite smooth and are iron-stained darker than the matrix, in these respects resembling the hollows left by Echinoderm fragments in many another sandstone. Moreover, the fractured rock surfaces of the British Museum specimens under discussion do show imprints in places, whether of dermal armour and scales, or abdominal ribs, or perhaps fragments of some other creatures; and all the markings

clearly recognizable as of organic origin have a smooth surface. But wherever or whatever the markings perceived by Dr. Burckhardt may be, their whole surface is admittedly rough with "the coarse grains of the sand," and they show no distinctive colour.

"In size" these impressions are said by Professor Burckhardt to "vary between 3 mm. and 3 cm. in diameter." Now Echinoderm plates or tests of this area must have had an appreciable thickness, and this thickness would be manifest in their hollow casts, since the rock has undergone no extraordinary pressure. Therefore the spaces should be visible in section wherever the rock is broken at a sharp angle. But Dr. Burckhardt, who had a piece of the matrix specially chipped off for examination, will doubtless admit that such is not the case.

If the matrix did contain impressions or moulds of Echinoderm objects of the nature described by Professor Burckhardt, one would certainly expect to find them lying roughly parallel to the plane of stratification, and we are indeed told that these bodies are "all of them lying in the same plane as the skeleton of *Hyperodapedon*." But the skeleton in question is a large, irregular object, and the exposed surfaces along which the matrix has been fractured are not in any one plane, but lie at various angles. There is no trace of lamination, and if any objects ever did lie on the rough fracture-surfaces, they must have been deposited in most irregular fashion, and the sandy floor of the Triassic lagoon in which these reptile skeletons lay undisturbed must have been unlike any sea-bed before or since. But it is well known that the Elgin sandstones are quite objectionably like dozens of other sandstones, and one cannot doubt that were Professor Burckhardt to pursue the geological studies he finds so attractive, he would discover equally clear or equally obscure appearances, in many rocks besides those "fragments from the Maleri deposits in India."

We conclude, then, that the phenomena described by the learned professor are mainly subjective, such objective basis as they possess being furnished solely by the mechanical arrangement of sand-grains and the natural irregularity of a broken surface.

VIII.—On the Pectoral Fin of *Cœlacanthus*.

By Edgar D. Wellburn, L.R.C.P., F.G.S., F.R.I.P.H., etc.

AMONG the fossil fishes of the Talbragar Beds (Jurassic?) described by Dr. A. Smith Woodward in a memoir of the Geological Survey of New South Wales (1895), there is the ventral portion of the abdominal region of a Cœlacanth fish, having one of the pectoral fins well shown. The fin is shown in counterpart, and is thus described:—"It exhibits, as usual, the characteristic obtuse lobation and the large fringe of articulated attenuated dermal rays, and is unique in displaying some of the endoskeletal supporting bones. These elements seem to have been well ossified, though with persistent cartilage internally. At the base of the fin there occurs a broken fragment of bone [1] incapable of determination; but

[1] My specimen would point to the fact that this is a fragment of the clavicle.

in the lobe of the fin itself there is a series of four well-defined, hourglass-shaped supports. Of these bones the anterior three are much elongated, and nearly equally slender, while the fourth is much more robust and expanded at its distal end. The four elements radiate from the anterior half of the base of the fin; and it seems very probable that some smaller cartilage behind and near the distal border of the lobe have disappeared from lack of ossification. The fin-rays gradually increase in length from the anterior border to the middle of the lobe, whence they decrease again backwards, and finally become extremely delicate."

In my collection there is a specimen of *Cœlacanthus tingleyensis*, Davis, from the Cannel Coal, Middle Coal-measures, Tingley, Yorkshire, crushed vertically, which exhibits the pectoral fins, and one, the left, shows characters very similar to those given by Dr. Smith Woodward. The clavicle is well shown and springing from a point about its centre; and opposite to the process which is usually seen on these bones there are six basal supports, of which the anterior four are elongated and more or less uniform in thickness, the fifth is more nearly hourglass-shaped, and the sixth (fourth of Dr. Woodward ?) is more robust and widely expanded distally. No supports are seen posteriorly to the sixth, but as the dermal rays extend some distance behind this point, and as the lobe of the fin has here suffered somewhat from crushing, it seems highly probable that there were two, if not three, supports posterior to the sixth, but that they have in the specimen been destroyed during fossilization. At their distal extremities each support is opposed to two or more of the dermal rays, which, as pointed out by Dr. Woodward, "increase in length from the anterior border to the middle of the lobe, whence they decrease backwards, and finally become extremely fine." All the rays are closely articulated distally.

From the above it will at once be seen, as pointed out by Dr. Woodward, that the pectoral fin of *Cœlacanthus* is a striking contrast to that of the existing Crossopterygian *Polypterus*, the basalia more closely approaching that of the Actinopterygii.

NOTICES OF MEMOIRS.

I.—The Movements of Underground Waters of Craven.[1]—First Report of the Committee, consisting of Professor W. W. Watts (Chairman), Mr. A. R. Dwerryhouse (Secretary), Professor A. Smithells, Rev. E. Jones, Mr. Walter Morrison, M.P., Mr. G. Bray, Rev. W. Lower Carter, Mr. W. Fairley, Mr. P. F. Kendall, and Mr. J. E. Marr. (Drawn up by the Secretary.)

THE Committee is carrying out the investigation in conjunction with a Committee of the Yorkshire Geological and Polytechnic Society. The present is merely an interim report, as the work is still in progress.

[1] Read before the British Association, Section C (Geology), Bradford, Sept., 1900.

It was decided that the first piece of work should consist of an investigation of the underground flow of water in Ingleborough. This hill forms with its neighbour, Simon's Fell, a detached massif, which is peculiarly suitable for investigations of this nature. The summit of the group is formed of Millstone Grit, then follow Yoredale Shales and Sandstones, the whole resting on a plateau of Carboniferous Limestone. Many streams rise on the upper slopes of the hills and flow over the Yoredales, but without exception their waters are swallowed directly they pass on to the Carboniferous Limestone, to reappear as springs in the valleys which trench the plateau.

The Committee first turned its attention to tracing the water which flows into Gaping Ghyll hole. It was generally believed that the water issued at a large spring immediately above the bridge at Clapham Beck Head and immediately below the entrance to Ingleborough Cavern. On April 28 specimens of the water from this spring were taken for analysis before the introduction of any test. Two cwt. of ammonium sulphate was then put into the water flowing into Gaping Ghyll, and at the same time the amount of the water was gauged and found to be equivalent to 251,856 gallons per diem. A few hours later a second quantity of 2 cwt. of the same substance was introduced. On the same day 1½ lb. of fluorescein in alkaline solution was put into a pot-hole known as Long Kin East, about 1,300 yards north-east of Gaping Ghyll.

In view of the important influence which the direction of the joints in the limestone had been found to exercise over the flow of underground water,[1] the direction of the joints in the limestone clints in the neighbourhood of Long Kin East was taken, and was found to be N.N.W. to S.S.E., and to run in such a direction as to lead to the probability that the water would reappear at the springs at the head of Austwick Beck, and these were consequently watched.

The ammonium sulphate put in at Gaping Ghyll reappeared at the large spring at Clapham Beck Head on the morning of May 3, and continued to flow until the evening of May 6, when the water again became normal. Thus the time occupied by the ammonium sulphate in travelling from Gaping Ghyll to Clapham Beck Head, a distance of one mile, was about five days. No ammonium sulphate was found in any of the other springs in Clapdale. This result proved beyond doubt that Gaping Ghyll was connected with Clapham Beck Head.

The fluorescein put in at Long Kin East showed itself at Austwick Beck Head, but not at any of the neighbouring springs, on May 11, having taken over thirteen days to travel, the delay being probably due to the small amount of water flowing at the time of the experiments.

These results are of considerable importance, as they definitely reveal two lines of divergent movement of these underground waters, and indicate a subterranean watershed of much interest.

[1] See previous investigations of the Yorks. Geol. and Polyt. Soc. Committee.

The influence of the master-joints of the Carboniferous Limestone in determining the direction of flow of these underground waters was also, as at Malham, clearly shown.

The next set of experiments was carried out by the joint Committee on June 8 and following days.

In order to confirm the results in connection with the Gaping Ghyll to Clapham Beck Head flow, and further to ascertain more definitely if there existed any connection between Gaping Ghyll and the smaller springs in Clapdale, 10 cwt. of common salt was put into the waters of Gaping Ghyll on June 4, and a further 10 cwt. on June 5, samples of the water from each of the springs being taken several times a day until June 25.

One pound of fluorescein in alkaline solution was introduced into the stream flowing through Ingleborough Cave on June 8 at 10 p.m., at the point where the water plunges down a hole in the floor of the cave, and marked 'Abyss' in the 6-inch Ordnance map. Five cwt. of ammonium sulphate was introduced into a sink on the allotment, about 500 yards north-east of Long Kin East, on June 9, at 3 p.m.; and at 3·15 p.m. on the same day 1 lb. of fluorescein in alkaline solution was poured into the stream which flows past the shooting-box on the allotment and sinks near the Bench Mark 1320·1.

The fluorescein introduced into the abyss came out of Clapham Beck Head, and possibly at Moses Well and other springs in Clapdale, but this point requires further investigation, the evidence being as yet somewhat unsatisfactory. The salt from Gaping Ghyll appeared at Clapham Beck Head on June 15, 16, 17, 18, 19, 20, and 21, being at its maximum on June 18, but not at any of the other springs.

The ammonium sulphate put into the sink on the allotment appeared at Austwick Beck Head on June 22, the other springs in the neighbourhood being unaffected on that day; but on the 24th and 25th there were slight increases in the amount of ammonia in two small springs in Clapdale, viz., the small spring below Clapdale Farm and Cat Hole Sike. As one of these streams is close to the farmyard, and the other was at the time nearly dry and flowing through pasture land, no importance is attached to these slight increases. Of the fluorescein put in below the shooting-box no trace has since been found, and the same is the case with $\frac{1}{2}$ lb. of methylene blue introduced into Grey Wife Sike, above Newby Cote.

Several most interesting problems still await solution in this area, one of them being the relations of the Silurian floor which underlies the Carboniferous Limestone of the plateau to the flow of underground water. The two sinks Gaping Ghyll and Long Kin East are only about 1,300 yards apart, and yet the waters of the one take a direction quite distinct from those of the other, and eventually emerge in a separate valley, the distance between the springs being $1\frac{1}{2}$ miles apart, the great mass of Carboniferous Limestone known as Norber, a hill upwards of 1,300 feet in height, lying between the two valleys. In Crummack Dale it is seen that the Silurian rocks

form a ridge running in an approximately north-west and south-east direction, and unconformably overlain by the Carboniferous Limestone. If this line be continued it separates the Gaping Ghyll to Clapham Beck Head flow from that of Long Kin East to Austwick Beck Head. Thus it appears that this ridge of Silurian rocks forms an underground water-parting, which the Committee hopes to be able to trace for a considerable distance across the area.

The magnitude of this undertaking will be to some extent realized when it is stated that upwards of 400 samples of water have been tested for common salt, ammonium, and fluorescein, making in all upwards of 1,200 tests. The whole of the grant of £40 has been spent upon the investigation, and a small sum in addition. The experiments which have been carried out have indicated which are the most suitable reagents for use in different cases, and it is consequently hoped that future investigations will be carried out at rather less cost than has been the case up to the present. The Committee ask to be reappointed, with a grant of £50.

II.—The Underground Waters of North-West Yorkshire.[1]

By Rev. W. Lower Carter, M.A., F.G.S., Hon. Sec. Underground Waters Committee, Yorkshire Geological and Polytechnic Society.

Part I. The Sources of the Aire.

THE Silurian and Carboniferous rocks between Malham Tarn and Malham are traversed by two branches of the Craven Fault with the downthrow to the south. Malham Tarn lies on Silurian, and its overflow sinks in the limestone directly the northern fault is crossed. The drainage of the area to the west of the Tarn disappears at the Smelt Mill Sink. The drainage of the area east of the Tarn is carried off by Gordale Beck, along the course of which some water sinks into the jointed limestone. To these three sinks correspond three principal outlets, the stream at Malham Cove, Aire Head Springs, and the springs at the bottom of Gordale.

The history of previous investigations is then given. From the centre of Malham Cove a dry limestone gorge runs in a northerly direction to the Tarn. Up to the beginning of this century flood-waters were known to traverse this valley and discharge over the Cove. There are several sinks along the line of this dry valley. Now all the overflow is taken by three sinks south of the Tarn.

Various efforts have been made to trace the connection between the sinks and outlets. Flushes of water from the Tarn have been shown to affect Aire Head before Malham Cove. Experiments by introducing chaff, bran, magenta, and uranin into the sinks failed to show any traces at the outlets.

The present investigation was carried out during 1899, by a Committee of Engineers, Chemists, and Geologists, appointed by the Yorkshire Geological and Polytechnic Society. Flushes of water were sent down from the Tarn to the Tarn Water Sinks.

[1] Read before the British Association, Section C (Geology), Bradford, Sept., 1900.

Aire Head Springs responded in two hours. With large flushes a rise in Malham Beck was also observed.

The chemical investigations were as follows:—

Ammonium sulphate was put in below the Malham Tarn Sluice on June 22, and appeared at Aire Head from July 4 to 11. Distinct traces were also found at Malham Cove on the same dates.

Common salt and fluorescein, put in at the Smelt Mill Sink between June 22 and 28, appeared at Malham Cove from July 4 to 11.

Fluorescein, put in at Tranlands Beck on June 22, appeared at Scalegill Mill on June 23.

Ammonium sulphate, put into upper Gordale Beck on August 26, appeared at the springs below Gordale Scar on September 7.

Common salt, put into Cawden 'Burst' on September 18, appeared at Mire's Barn from September 23 to 27.

Fluorescein put into the bottom of Grey Gill Cave was not traced.

A geological investigation of the area showed that the limestone is traversed by two sets of prominent joints, of which the master-joints, which run in a north-west to south-east direction, are very well developed. These master-joints are found to largely determine the flow of the underground waters. The direction of these master-joints unites the Smelt Mill Sinks and Malham Cove directly, and that may be taken as the direction of flow. A parallel line from Malham Tarn Sinks would bring the water from them to Grey Gill, a dry valley in the escarpment to the east of Malham Cove. No evidences of moving water were found there.

To the south of the Mid-Craven Fault the jointing of the limestone is found to be variable; but prominent joints were found bearing in a north-east and south-west direction. If the Tarn water followed these joints on crossing the fault it would traverse a direction almost at right angles to its previous course, and following the limestone in its bend underneath a synclinal of Yoredale shale, would be likely to reappear at Aire Head Springs, which is the nearest point for re-emergence on the southern side of the anticlinal.

The master-joints north of the Mid-Craven Fault would similarly carry the water which sinks into the bed of Gordale Beck south-eastward into the limestone, and if, as it nears the fault, it followed a set of joints running at right angles to the previous set, it would come out at the springs at the foot of Gordale Scar, which was found to be the case by the chemical tests. Gordale itself turns in this direction from some cause.

The conclusions of the Committee are:—

1. That Malham Cove Spring discharges the water from Smelt Mill Sink and the limestone area west of the dry valley; and under certain conditions some of the Tarn water.

2. That Aire Head Springs discharge the main portion of the water disappearing down Malham Tarn Water Sinks.

3. That Gordale Beck Springs discharge the water sinking in Upper Gordale.

4. That chemicals put into Cawden 'Burst' appeared at Mire's Barn.

5. That Tranlands Beck Sinks discharge at Scalegill Mill.

6. The investigations show that within the area the main direction of underground flow is along the master-joints of the limestone.

III. — The Caves and Pot-holes of Ingleborough and the District.[1] By S. W. Cuttriss.

THE portion of Yorkshire to which this paper refers is contained in Sheets 49, 50, and 60 (New Series) of the 1-inch Ordnance Survey. The great Craven Faults which traverse it in a north-west to south-east direction have produced a difference of level of the strata of several thousands of feet; the limestones on the south side of the Faults being far below the surface.

The Silurian slates and grits form the basement beds, and are exposed in several of the valleys. On these rests the Carboniferous Limestone, which has a thickness of about 500 feet from the base to the present exposed surface on Ingleborough. The name Carboniferous Limestone is here applied only to distinguish a particular bed of rock in the district. Above this are a series of thinner limestones, shales, and sandstones (the Yoredales of Professor Phillips), capped by Millstone Grit.

Towards the west the Carboniferous Limestone has been cut off by the Dent Fault, while the Craven Faults determine its extension towards the south. The main line of fault passes through Ingleton, Clapham, and Austwick to Settle, then eastwards by Malham. North of this is another fault, near the first at Austwick, but about 1½ miles apart at Malham. Further north the most interesting caves and pot-holes are found in an area comprising the Leck Fells, Kingsdale, Chapel-le-Dale, Ribblesdale, and around Ingleborough.

The whole area may be divided into three sections:—

1. The Yoredales, comprising the rocks of that name. These limestones being comparatively thin, and intercalated with beds of shale and sandstone, the caves are small and obstructed with earth, through which the water percolates. They are at an elevation of from 1,300 to 1,600 feet, and do not materially affect the drainage of the ground.

2. The Southern Carboniferous, including the Carboniferous Limestone between the two Craven Faults. Although part of the same formation as the Carboniferous Limestone north of the Fault, yet the caves in the two sections differ entirely in their characteristics. Here they are distinguished by an absence of running water, the walls are covered with a considerable thickness of calcareous deposit, and their entrances are blocked with clay and rock débris. The well-known Victoria and Attermire Caves are included in this section. A further characteristic is the entire absence of pot-holes—vertical chasms in the ground caused by falling water enlarging the rock fissures.

3. The Main Carboniferous, which includes the remainder of the Carboniferous Limestone within the area defined. Here there are no

[1] Read before the British Association, Section C (Geology), Bradford, Sept., 1900.

dry caves, all being active drainage channels. Pot-holes also are very abundant. In the Leck Fell and Kingsdale districts the caves are almost without exception those of engulfment, while in Chapel-le-Dale and Ribblesdale they are chiefly caves of débouchure. The first-named are usually low at the entrance. The passages then increase in height to 20 feet or more, but rarely exceed 6 feet in width, usually much narrower. Some may be traversed a quarter of a mile or more, such as Lost John's Cave, which terminates in a subterranean pot-hole over 100 feet deep. The caves of débouchure are much more numerous. The mouth is generally wide and shallow, with a flat roof. A cascade or waterfall is usually found some little distance in, beyond which the passage is a simple water-worn channel, gradually shallowing and broadening until too low to permit of further progress.

The pot-holes occur at or near the top of the limestone, at between 1,100 and 1,300 feet elevation, and always where there are surface streams, which fall into the chasms. Over thirty have been named, nearly all of which have been descended by the writer and friends, members of the Yorkshire Ramblers Club, many of them for the first time. Half the number are over 100 feet deep. Gaping Ghyll, on Ingleborough, attains a depth of 350 feet, and was first descended by Monsieur E. A. Martel, in 1895. Rowten Pot, in Kingsdale, was conquered in 1897, and found to be 365 feet deep, thus being the deepest known pot-hole in the country.

No evidence of the presence of the Silurian rocks has been found, the lowest observable rock being either light or black limestone. The average Summer temperature in both caves and pot-holes is 48° Fahr.

The writer has prepared a special map of the district on which are shown all the known caves and pot-holes, with the surface streams. Such a map illustrates in a forcible manner the interesting fact that the entire surface drainage of Ingleborough is swallowed up by the limestone. Not a single stream from the higher levels continues an uninterrupted course into the valley below.

IV.—The Outcrop of the Corallian Limestones of Elsworth and St. Ives.[1] By C. B. Wedd, B.A., F.G.S.

(Communicated by permission of the Director-General of the Geological Survey.)

THE ferruginous and oolitic limestones known as the Elsworth and St. Ives Rocks are now generally believed to be one and the same, an opinion supported by my own work in that district recently. The limestone in question has long been known to occur at St. Ives in brick-pits, being well exposed to the west of the town. It was known also to occur throughout the village of Elsworth. Mr. Cameron noticed a fossiliferous rock outcropping near Hilton, between Elsworth and St. Ives. No other surface exposures were known, but a similar rock was found in the railway cutting at Bluntisham, north-east of St. Ives, at Swavesey, east of the same

[1] Read before the British Association, Section C (Geology), Bradford, Sept., 1900.

place, and Bourn, south of Elsworth, and a few other localities, and like rock was found in Wells.

The outcrop can be traced almost continuously from a mile west of the brickyard at St. Ives, striking eastwards along the northern flank of the Ouse valley, and passing north of St. Ives to Needingworth; here it bends abruptly southwards to Holywell and forms a gentle rise. The southern part of the village of Holywell stands on a gravel-capped escarpment of the rock; a collection of fossils in the Woodwardian Museum, Cambridge, agreeing closely with those of the Elsworth and St. Ives Rocks, was believed to have come from Holywell. East of Holywell the outcrop must cross the Ouse valley; I found traces of the rock in a drain some distance west of Swavesey. From here, south-westwards, it is not seen again till it appears at the surface between Hilton and Conington, where a rock was noted by Mr. Cameron. Southwards from here the outcrop crosses a valley to the rising ground west of Elsworth, through which village a narrow tongue of the rock runs still further south. The main outcrop, however, flanks the northern slope of the drift-capped high ground to the west, and can be traced along the slope through Papworth Everard, westwards to Yelling, following the contour of the ground. At both of these localities there are good and highly fossiliferous exposures in streams. Thence the outcrop disappears southwards under drift, but the rock may be seen again to the south, less than two miles south of Croxton, in a ditch in the valley of the Abbotsley Brook.

To the north, east, and south-east of the line of outcrop of this limestone, the ground is occupied by Ampthill Clay, to the west by Oxford Clay. It will thus be seen that the Elsworth and St. Ives Rocks, besides agreeing closely in their fauna, outcrop along the same line of strike, with Ampthill Clay above and Oxford Clay below. The dip is always small, and the rock at Bluntisham, if it reaches the surface at all, does so probably as an inlier, though it may be directly connected at the surface with the outcrop east of St. Ives.

V.—On Rapid Changes in the Thickness and Character of the Coal-measures of North Staffordshire.[1] By W. Gibson, F.G.S.

(Communicated by permission of the Director-General of the Geological Survey.)

VARIABILITY in thickness and character of the strata is universal throughout the Carboniferous period, but is nowhere more marked in the Midlands than in the coalfield of the North Staffordshire Potteries.

This important coalfield consists of two portions. On the east the productive measures lie in a well-marked syncline, while on the west the strata rise in a sharp anticline extending from Silverdale to Talke. The two productive areas are separated by a strip of ground two and a half miles broad, composed of barren upper measures.

[1] Read before the British Association, Section C (Geology), Bradford, Sept., 1900.

A notable difference in the thickness of the strata and nature of the coal-seams characterizes these structurally distinct areas. In the centre of the syncline, near Shelton, the vertical distance between the highest ironstone, or summit of the productive measures, to the Bullhurst coal, or lowest workable seam, is about 1,300 yards. On the anticline at Apedale only 800 yards of strata separate the same horizons. This makes a remarkable decrease in thickness of 500 yards of strata in a distance of under three miles. The reduction in thickness westward of the productive measures is continued, though in a less degree, in the upper barren series, but owing to the absence of shaft sections the amount cannot be definitely stated. It is known, however, that the red marls forming the lower portion of the upper barren series are more than 1,000 feet thick near Etruria station on the Shelton property, and about 850 feet thick near Silverdale, on the south-eastern limb of the anticline. With the decrease in thickness a change has taken place in the lower coals of the productive series. The seams which are house or steam coals on the east change into gas and coking coals on the west.

This great variability seems to show that separate areas of deposit were being marked out by local movements of elevation and depression, and thus fulfilling in North Staffordshire the conditions characteristic of the Carboniferous of the Midlands generally, as pointed out by Professor Lapworth.[1]

In North Staffordshire it happens that the areas of maximum and minimum deposit correspond with a syncline and anticline. If this be true generally, and not merely a local coincidence, we may expect the coals in the unexplored coalfield which lies at the surface to the west of the anticline, and which represents the eastern margin of the great synclinal of Coal-measures beneath the Cheshire plain, to be of a different quality from those in the anticline, while the thickness of the measures will be increased.

VI.—On some Fossil Fish from the Millstone Grit Rocks.[2]

By Edgar D. Wellburn, F.G.S.

THE Millstone Grits are naturally grouped into three divisions, viz.: (1) Rough Rock; (2) Middle Grits; (3) Kinder Grits at base. The Middle Grits, consisting of grits, sand, shales, are subdivided into A, B, C, and D beds, A being uppermost. The Pennine Anticline is mostly composed of these rocks, and on the Lancashire side at the head of Calder Valley, on the south side in a quarry at the summit, there is a good exposure of the D shales; in these the majority of fish remains were found; a few occurred at the same horizon at Wadsworth Moor, Sowerby, Kilne House Wood, and Eccup, Yorkshire. The majority are in nodular masses, few in shales, and are associated with a marine fauna. The fish-bearing beds were formed under marine estuarine conditions. They are of great geological and zoological interest, as largely increasing

[1] "A Sketch of the Geology of the Birmingham District": Geol. Assoc., 1898, p. 364.

[2] Read before the British Association, Section C (Geology), Bradford, Sept., 1900.

our knowledge of the fish fauna in rocks whose yield of fish remains has hitherto been extremely limited; and zoologically inasmuch as (1) one genus and several species are new; (2) one Lower Old Red Sandstone fish is present; (3) the occurrence of the Lower Carboniferous types, *Orodus*, *Psephodus*, *Pristodus*. The author made some remarks on the fish remains, and exhibited a table of their stratigraphical distribution.

REVIEWS.

I.—The Geology of Central and Western Fife and Kinross. (Memoirs of the Geological Survey of Scotland.) By Sir Archibald Geikie, F.R.S., D.C.L., etc., Director-General. With Appendix of Fossils by B. N. Peach, F.R.S. 8vo, cloth; pp. x, 284. (Glasgow: printed for H.M. Stationery Office, 1900. Price 5*s*. 6*d*.)

THIS well-printed memoir is in the main a description of the geological formations which are represented in Sheet 40 of the Geological Survey map of Scotland, which was published in 1867. The ground was surveyed in part by the author, and in part by Mr. H. H. Howell, Prof. John Young, Prof. J. Geikie, and Mr. B. N. Peach, when Murchison was Director-General. It is not surprising, therefore, that the nomenclature, especially of the igneous rocks, has undergone considerable changes, noticeable when we compare the tablets on the map with the table on p. 13 of the memoir. Much additional information on the coalfields has, however, in recent years been obtained by Mr. J. S. Grant-Wilson, and the Director-General has himself revisited the area from time to time. Consequently every effort has been made to bring the information up to date by personal observation, and with the help of other workers whose publications are listed in the Appendix. It is needless to add that in point of style the memoir bears the most favourable comparison with any previously published by the Geological Survey.

The country described is a highly important one, extending from the Firth of Tay west of Tay bridge to the Firth of Forth at Queensferry. It is composed chiefly of Carboniferous rocks and Old Red Sandstone, with numerous interstratified and intrusive igneous rocks. In the northern part is the Ochil chain, formed mainly of hard lavas of Lower Old Red Sandstone age; the central part, in which lies Loch Leven, is hollowed out of comparatively soft red sandstones forming the plains of Kinross and the Howe of Fife; and in the southern part there is again a belt of hilly ground, more varied and broken than that in the north, and composed mainly of Carboniferous rocks with hard eruptive sheets, which form the Lomond Hills and other prominent heights.

While perusing the very interesting Introductory chapter it would have been useful to the reader to have had a small map depicting the main outlines of the geology and topography, with the names of

the chief hill ranges, rivers, and lakes. In succeeding chapters the author gives a full account of the strata, entering into many particulars concerning the eruptive rocks, and recording detailed sections of the coal-bearing strata in the Carboniferous Limestone series and Coal-measures. In this great series the highest division is the "Upper or Barren Red Sandstone Group," composed of red, purple, grey, yellow, white, and variegated sandstones, shales, clays, and marls, with some thin limestones and poor coals. Many fossils have been obtained in this group by Mr. J. W. Kirkby, including fishes (*Diplodus, Megalichthys*, etc.), crustacea (*Bellinurus, Eurypterus, Prestwichia*, etc.), as well as molluscs such as *Anthracomya* and the annelide *Spirorbis pusillus*. Full lists of them and of fossils from the other formations are given by Mr. Peach in the Appendix; special mention being made of the long and enthusiastic labours of Mr. Kirkby.

Sir A. Geikie remarks that "The topography of the whole region has been profoundly modified by the geological events of the Ice Age. So thick was the mass of ice which then descended from the Highlands, that it passed over the lofty ridge of the Ochils and the other hills to the south, and turned eastwards into what is now the Firth of Forth and the North Sea." Of the glacial deposits, and also of Recent deposits and the latest changes, many interesting descriptions are given; and there is a final chapter on the Economic Minerals. Some detailed notes on the petrography of the Igneous rocks are contributed by Mr. Herbert Kynaston, in an appendix.

II.—Memoirs of the Geological Survey of the United Kingdom. The Cretaceous Rocks of Britain. Vol. I. The Gault and Upper Greensand of England. By A. J. Jukes-Browne, B.A., F.G.S.; with contributions by William Hill, F.G.S. Royal 8vo; pp. xiv, 499, with 85 figures and 5 plates. (London: Wyman & Sons, 1900. Price 9*s*.)

IN the preface Sir Archibald Geikie, the Director-General of the Geological Survey, states that the present volume is the first of two in which the Upper Cretaceous Rocks of England will be described by Mr. Jukes-Browne, who has been collecting the materials for the subject since 1884. Owing, however, to his unfortunate ill-health, he has been unable to complete the necessary field-work, but this obstacle has been overcome by the assistance of his friend and coadjutor Mr. William Hill, who has examined the outcrops of the formations in the South and East of England, and in addition has carried out a series of important researches on the mineral and organic constituents of the deposits by means of microscopic sections and the examination of residues after treatment with acid.

The strata described in this volume have, since early days, attracted the attention of many of our British geologists, amongst whom may be reckoned William Smith, Thomas Webster, William Phillips, Dr. Mantell, Dr. Fitton, Sir R. Murchison, and R. A. C. Godwin-Austen. At a more recent period, Mr. C. J. A. Meyer, Mr. F. G. H.

Price, Dr. Charles Barrois, and others have studied their stratigraphy and fossils in more detail. They have also been described in some of the previously published memoirs of the Geological Survey, as in those on the Isle of Wight by A. Strahan, on the Isle of Purbeck by A. Strahan, those on West Suffolk and West Norfolk by W. Whitaker and A. J. Jukes-Browne, and that in the neighbourhood of Cambridge by W. H. Penning and A. J. Jukes-Browne. Chemical analyses of the rocks, besides those already published, have been made by Professor J. B. Harrison, Mr. Berry, and Dr. W. Pollard. Mr. F. Chapman has determined the foraminifera of the Gault, whilst the author and Mr. E. T. Newton, assisted by Mr. H. A. Allen and Dr. Kitchin, have revised the synonymy of the rest of the fauna. The author has made use of the knowledge to be obtained from the above and other writers on the geology of these rocks to add to his own observations, and thus render the monograph as complete as possible.

The first chapter contains the introduction to the Upper Cretaceous Series, which is regarded as consisting of the following four stages or groups of strata :—

4. Upper Chalk.
3. Middle Chalk.
2. Lower Chalk.
1. Gault and Upper Greensand (Selbornian).

The combined thickness of these stages where the series is most fully developed, as in the Isle of Wight, is about 1,900 feet. The Upper Series, on the whole, succeeds conformably the Lower Cretaceous Series, but there is evidence of a very general subsidence of the region at an early period of the Upper Series, which produced an overlap of the Lower Greensand by the Gault. In deep borings in the East of England, the Gault is known to rest directly on Palæozoic rocks, whilst in a westerly direction it is deposited successively on Wealden, Jurassic, and Rhætic beds, and in the Haldon Hills Greensand rests on the lower part of the New Red Series. The general dip of the Upper Cretaceous is easterly, but this is interrupted by several anticlinal flexures with an east and west direction, which produce local dips to the north and south. The most important of these are (1) that traversing South Dorset and the Isle of Wight, which is believed to be continuous with the anticlinal axis of the Pays de Bray; (2) a series of local and parallel flexures in a tract extending from the Vales of Wardour and Warminster through Central Hants and the southern part of Sussex; and (3) the anticlinal axis which runs through the Vales of Pewsey and Kingsclere.

Chapter ii, giving an historical account of the Chalk, Upper Greensand, and Gault, mainly deals with the origin of the term 'Upper Greensand.' The name 'Greensand' was used by William Smith and T. Webster for the greensands, including also the Malm or Firestone, between the Chalk and the Gault. Subsequently, W. Phillips and Dr. Mantell mistook the sands below the Gault

(Lower Greensand) for the Greensand of William Smith, which gave rise to much confusion. The true succession of the beds was pointed out by Dr. Fitton in 1824, who suggested the name of *Merstham Beds* for the firestone and greensand above the Gault and *Shanklin Sands* for the sands below. The proposition of Webster that the beds should be respectively called 'Upper Greensand' and 'Lower Greensand' finally prevailed, and these terms were adopted by the Geological Survey in 1839 and have since continued in general use.

It was not until a later date that the accepted character of the Gault and Upper Greensand as definite and distinct formations of the Cretaceous System was called in question. Mr. Godwin-Austen stated in 1850 that the Upper Greensand was a purely conventional name, and that the differences between the fauna of the Devizes and Blackdown Beds (Upper Greensand) and that of the Upper Gault of Folkestone are only such as might be expected between arenaceous and argillaceous portions of the same zone. He further added that the Gault was not an independent formation, but merely the accumulation of a given condition of deep-sea, synchronous as a whole with that portion of the Cretaceous deposits which we call Upper Greensand. Godwin-Austen's views were supported and confirmed by the investigations of Meyer, Price, Dr. Barrois, and more especially by the author of this memoir, who maintained that the Gault and Upper Greensand were merely different lithological facies of one group of deposits. For the new group the name 'Selbornian' is proposed by Jukes-Browne after the well-known Hampshire village made famous by Gilbert White the naturalist. The name is the more appropriate as the village is situated on the Malmstone, and the Gault clays are well developed near by. The author does not propose that 'Selbornian' should supersede the terms Gault and Greensand, but that it should be employed in a similar relation to them as the general term Wealden to the Weald Clay and Hastings Sands. It is strange that this new term, though constantly used throughout the memoir, should not have found a place on the title-page. In justification of its introduction the author states—

"As a matter of fact *gault clay* and *greensand* are only two of the different kinds of deposits that make up the group for which the name Selbornian is now proposed; it is only by a stretch of the imagination that malmstone can be called greensand, inasmuch as an ordinary malm contains but a small proportion of quartz sand and still less glauconite, so that it is not a sand nor is its colour green. There are large areas over which the formation is really a tripartite one, and could actually be mapped as consisting of *Gault*, *Malmstone*, and *Greensand*; there are also areas where it consists wholly of Gault, i.e. of grey clays and marls; others, again, where it consists entirely of sand and sandstone; and finally, there is a large area where it is neither the one nor the other, but is represented by red chalky limestone and red marl."

Chapter iii, on the value of zones in the Cretaceous System, comes in here somewhat parenthetically, but, as hinted in the preface, it

may be regarded as in some measure introductory to the completed monograph on the Cretaceous System. In it the author places on record some of the conclusions drawn from a study of the zones in this system, "especially with respect to the proper conception of a zone, the use of an index species, and the limitations which must be placed to the zonal method." To give a succinct explanation of a zone is by no means easy; the author says that "perhaps it may be defined as a band of sedimentary material within which certain species are either restricted or are specially abundant, and during the formation of which certain species acquired their greatest exuberance and their greatest geographical extension. More than this, however, is implied by the modern idea of the term *zone*, for a zone is only one of several successive zones; it is not merely a specially fossiliferous band in a thick mass of sediment, but is a subdivision of such a mass or group of beds; such a group being generally divisible into two, three, or more zones, one succeeding another." The above definition seems to us open to much criticism, which, however, cannot be entered on here; we should prefer the shorter definition of Mr. J. E. Marr, here quoted: "Zones are belts of strata, each of which is characterized by an assemblage of organic remains, of which one abundant and characteristic form is chosen as an index."

A general account of the Gault and Upper Greensand (Selbornian) is given in Chapter iv, and it is claimed that the clays, marls, sands, and sandstones of this Selbornian stage fall naturally into three groups or sub-stages: (1) Lower Gault; (2) Upper Gault and Devizes Beds; (3) Warminster Beds.

Hitherto it has been usual in England to consider the clayey beds containing *Ammonites interruptus* as the base of the Gault, and the underlying sandy beds as belonging to the Lower Greensand. In the uppermost beds of these lower sands at Folkestone and in three other localities in the South of England *Ammonites mammillatus* has been met with, whilst in France the same species occurs in a zone of fossiliferous sandy beds in association with *Am. interruptus*, and by French geologists these beds are included in the Albian as part of the basement bed of the Gault. The author considers this will justify placing the sands with this fossil as the base of the Gault in this country, although it has never been found here associated with *Am. interruptus*.

The zone of clays with phosphatic nodules at its base, containing *Am. interruptus*, forming bed 1 of Mr. Price, is about 10 feet in thickness at Folkestone and from 20 to 50 feet in the Midland Counties. The upper part of the Lower Gault, which includes Price's beds 2–7, is placed in the zone of *Am. lautus*. It can be distinguished near Devizes, and is believed to form the larger part of the Lower Gault in Oxfordshire and the adjoining counties. The thickness of the Lower Gault in different parts of the country varies between 34 feet and 200 feet, but there is much difficulty in determining with certainty where a line can be drawn between the Lower Gault and the Upper in many areas.

The next division comprises the Upper Gault and Upper Greensand

(in part)—the Merstham or Devizes Beds, which are placed in the zone of *Ammonites rostratus*. The lower portions of this zone consists of marly clays, and above these are the well-known beds of Malmstone or Firestone, siliceous rocks with a considerable amount of silica in the colloid state, which has been derived from the spicules of siliceous sponges. This Malmstone occupies a large area in the South of England estimated at nearly 4,000 square miles. It extends from near Westerham, Kent, on the east, and from its thickness along the western outcrop the author believes that it stretched originally far to the westward over the counties of Oxford, North Wilts, and Gloucestershire. This Malmstone passes into a fine-grained micaceous sandstone.

In the Isle of Wight and in the South-West of England, a large portion of this zone of *Am. rostratus* consists of fine soft sands with intermediate beds of hard calcareous sandstone; in some places the cemented materials take the form of oval or rounded doggers or burr-stones. Again, in the Blackdown Hills of Devonshire and near Stourton in Wiltshire, the sands of this zone contain siliceous nodular accretions, formerly worked for whetstones, the silica in which is derived from sponge remains.

The third division of the Selbornian comprises the highest portion of the Upper Greensand, and as this is most highly developed near Warminster it is known as the Warminster Beds, and included in the zone of *Pecten asper* and *Cardiaster fossarius*. The zone of *Pecten asper* near Warminster includes three sets of beds: (1) Greensand and sandstone; (2) fine grey sand with layers and nodules of chert; and (3) a light greensand with calcareous concretions, which forms the highest portion of the series and contains the well-known Warminster fauna. The author states that no Ammonite or other Cephalopod has yet been found in this zone which does not range into the Chalk above or into the beds below.

Pecten asper, the principal index fossil of this zone, has a wide distribution both in this country and in France. In England it has been found in the Malmstone of Hampshire, that is, in the zone of *Am. rostratus*, and occasionally it occurs in the same zone in France. In the zone distinguished by its name it is found near Warminster and other places in Wiltshire, also in Dorset, and the Isle of Wight. It passes up into the Chloritic Marl, and occurs in the nodule bed at the base of the Chalk near Chard, and in certain beds of Cenomanian age in Devonshire. In France also this species is common in the 'craie glauconieuse,' the equivalent of our Lower Chalk. Its mere occurrence, therefore, cannot be considered as proof that the bed containing it belongs to the Upper Greensand.

The Warminster or *Pecten asper* division of the Upper Greensand is confined to the south-western and south-central counties from the Isle of Wight to Buckinghamshire. Its maximum thickness is estimated at 60 feet, but where the chert beds are not present it is reduced to about 12 feet. The well-known chert beds of the Undercliff in the Isle of Wight are included in this division.

Chapters v–xxii give detailed descriptions of the varying features

of the zones of the Selbornian as they are exposed in different counties, beginning with the easterly exposure on the coast at Folkestone to its most westerly extension on the Haldon Hills, near Exeter, from thence returning in a north-easterly direction through the counties of Wilts, Berks, Oxford, Buckingham, Cambridge, Norfolk, Lincoln, and York. The changes in the character of the beds in areas not far removed are somewhat striking: we can only briefly mention some of them.

Beginning at the well-known coast section at Folkestone, the Lower Gault (excluding the debateable 6 feet of sand of the *Am. mammillatus* zone) consists mainly of grey and dark fossiliferous clays, about 29 feet in thickness. The lower portion of the Upper Gault is likewise of marly clays, having a thickness of 50 feet, and these are overlaid by glauconitic sands and buff marls with but a few fossils, 27 feet in thickness. Thus the total thickness of the Selbornian at this spot is 106 feet, and the materials are mostly marly or clayey.

In Surrey the Lower Gault consists of clays somewhat similar to those in Kent, but fossils are comparatively scarce in them. No definite boundary between the Upper and Lower Gault is known: the upper beds are of a more sandy character, and they are succeeded by the Malm and Firestone (Merstham Beds), representing the Upper Gault and Upper Greensand, which are 60–80 feet in thickness in the west of the county. The author considers that the entire thickness of the Malmstone belongs to the zone of *Am. rostratus*, together with the 8–10 feet bed of greenish sand which comes in between the Malmstone and the base of the Chalk Marl, and that the zone of *Pecten asper* is not represented. We do not find any reference to the excellent section of the Merstham Beds exposed in the last two or three years in the new cutting of the London, Brighton, and South Coast Railway at Merstham.

The Selbornian is well shown in the coast sections of South Dorset and Devon from Golden Cap to Axmouth. The lowest beds are, at Golden Cap, pebbles, sands, and sandy clays, resting on the Lias, nearly 30 feet in thickness; they contain Gault fossils, and are referred to the upper part of the Lower Gault; above these is a series of greenish and yellowish glauconitic sands, about 100 feet in thickness, which may represent the zone of *Am. rostratus*, and over these are some thin chert beds. Further westward, at Black Ven, the sandy beds representing the Gault, containing some obscure fossils, reach a thickness of about 180 feet, and the overlying chert beds, belonging to the highest division of the Upper Greensand, are 40 feet in thickness.

At Whitecliff, South Devon, the sands below the chert beds, forming the lower division of the Upper Greensand, contain the same fossils as occur in the Blackdown Beds, and are included in the zone of *Am. rostratus*. They are less than 90 feet in thickness. At Hooken Cliff and Whitecliff, the chert beds of the highest division of the Upper Greensand reach a maximum thickness of 70–80 feet: they contain species of *Exogyra* and *Orbitolina concava*, but *Pecten*

asper has not been found in them or in the topmost bed of calcareous sandstone.

In Oxfordshire and Buckinghamshire the Lower and Upper Gault clays have been proved by borings in various places to reach a thickness of 144–230 feet. Fossils occur in the Lower Gault which elsewhere in the South-East of England are only found in Upper Gault; for example, *Am. rostratus*, *Am. varicosus*, and *Am. cristatus* are associated with *Am. lautus*, *Am. splendens*, and *Am. tuberculatus*. The Upper Gault becomes marly, and passes into a micaceous marl and malmstone.

At Stoke Ferry in West Norfolk the Lower and Upper Gault is represented by a blue clay about 56 feet in thickness; more than half of it probably belongs to the zone of *Am. rostratus*. Northwards the clay is replaced by calcareous material and gradually thins out, so that at Hunstanton there is only about $3\frac{1}{2}$ feet of red earthy limestone between the sands of the Lower Cretaceous and the Lower Chalk. The author and Mr. Hill maintain the view put forward by them in 1886 that the Red Chalk is the actual stratigraphical equivalent of the Gault. They also agree with Dr. Barrois that the zone of *Pecten asper* is wanting in Norfolk, and that there is a direct passage from the Red Chalk to the Chalk Marl.

The Red Chalk is shown again in Lincolnshire and in Yorkshire, where it gradually passes into a stiff red marl with calcareous nodules. Mr. F. Chapman has recorded 86 species of Foraminifera from this rock in Norfolk and Yorkshire, and 52 of these, or about 60 per cent, have been found in the Gault of Folkestone, whilst only 25 occur in bed 2 of the Chalk Marl of Eastwear Bay, thus indicating that the Red Chalk has a closer relation to the Upper Gault than to the Chalk Marl.

In Chapters xxiv and xxv Mr. W. Hill describes the microscopical structure and the mineral ingredients of the Gault, Red Chalk, Greensands, Malmstones, etc. The Gault marls and clays consist in part of very finely divided, apparently structureless material, without reaction in polarized light between crossed nicols; in part of fine detritus of quartz, mica, and glauconite, with entire and fragmentary tests of organisms. Thin microscopic sections of the Gault do not give good results, and its characters were best ascertained by washing and sifting different samples.

The coarser particles of quartz, mica, and felspar fragments form but a small proportion in typical Gault clays. Zircon, rutile, tourmaline, magnetite, ilmenite, garnet, and cyanite were also recognized by Mr. Teall. The glauconite occurs in irregular rounded and mammillated grains, seldom more than 0·5 mm. in diameter, also as minute cylindrical rods, apparently moulded in the canals of sponge spicules. Marcasite (disulphide of iron) is also present in the form of small spherules, cylinders, and irregular masses.

Mr. Chapman has determined 265 species and varieties of Foraminifera from the Gault at Folkestone, and 66 species of

Ostracoda are also present with them. The tests of the Gault Foraminifera have been but little altered in fossilization, and they differ but slightly in appearance from those in recent deep-sea deposits. Molluscan shell fragments and prisms occur in all Gaults, but siliceous organisms such as sponge spicules are rare. Mr. Chapman has estimated the mean depth of the Lower Gault sea at 830 fathoms and that of the Upper Gault at 866 fathoms, basing his conclusions on the Foraminifera, but Mr. Jukes-Browne considers these estimates to be excessive. The Gault, on the whole, bears considerable resemblance to the Blue and Green Muds of modern seas.

Typical Malmstone is shown by Mr. Hill to consist principally of colloid silica with usually a small proportion—10–12 per cent.—of quartz sand; other varieties are more or less calcareous. Besides quartz sand, mica and glauconite are present in varying amounts.

The characteristic organic remains of the Malm and Firestone (Gaize), and also of the beds and nodules of chert, are the detached microscopic spicules of disintegrated siliceous sponges, of which these rocks are mainly composed. In the Malmstone the spicules are mostly of colloid silica, but in the cherts they are generally of chalcedonic and crystalline silica. Frequently the spicules are partially or entirely dissolved, leaving minute empty hollows, and the rock is then of a light porous character. The dissolved silica of the spicules is, in the Malm rock, often deposited in the form of very minute globules or discs, in the cherts it forms a hard glassy rock.

The occurrence of such thick and widely extended masses of Malmstone in the zone of *Am. rostratus* and of the chert layers and nodules in the highest part of the Upper Greensand in the so-called zone of *Pecten asper*, both largely derived from the remains of siliceous sponges (they have been termed Sponge-beds by Hinde), forms the most striking feature of the Selbornian stage.

In Chapters xxvi–xxix the underground extensions of the Gault and Greensand, as shown by various deep borings in the London and Hampshire Basins and the Eastern Counties, are referred to; the characters of the equivalent formations in Northern France are given, with lists of fossils compiled by Dr. Barrois, Mr. Price, and M. Delatour; the physical and geographical conditions under which the Gault and Upper Greensand were deposited are discussed, and the water supply and economic products are enumerated.

In an appendix critical remarks on some species of fossils are contributed by Mr. E. T. Newton and Mr. A. J. Jukes-Browne, and these are followed by an elaborate and exhaustive list of fossils of the Selbornian, showing the particular zones and indicating also the localities where they occur.

III.—The Scenery and Geology of the Peak of Derbyshire. By Elizabeth Dale. pp. 166 and index, with 16 plates, 16 views, and a map. (London: Sampson Low, Marston, & Co. Price 6s.)

THIS is a tall, attractive-looking volume, with numerous illustrations and plates; the former, however, have had scant justice done to them, and the original photographs have suffered much in the

process of reproduction. The plates, as is stated in the preface, are very largely borrowed from previous works; but why are they not numbered in direct sequence, and why does the map include only the southern escarpment of Kinder Scout, 'the Peak'? In the preface the authoress states that her object has been to make the book serve as an introduction to the study of the science of geology; consequently the book treats of a much wider subject than one might judge from the title, and we are dealing with a work on elementary theoretical geology, with illustrations drawn from a certain district. But even so, the authoress has not stuck to her text, for the country illustrated and described is larger than the Peak, and takes in other parts of Derbyshire and North Staffordshire. It had been better, we think, to have given the book its proper title, in the interests of the possible purchaser, who, misled by the title, finds himself let in for a *pot pourri* of bygone and current geological views and speculations, rather than a description of the glorious scenery of the Peak and its geology.

Chap. i (pp. 1–15) starts, *ab initio*, with the nebular hypothesis, and then proceeds to explain what is meant by the order of superposition, dutifully reproducing the time-honoured illustration of the pile of books. Of course there follow tables of sequence of strata, and a short account of the greater subdivisions of stratified rocks and their contents; and the last two pages conclude with a brief account of the 1 inch geological map of the rocks round Buxton, as seen in a bird's-eye view of the country from Grinlow. This is not perhaps the best way of commencing the study of geology. Miss Dale is eminently conservative, and while mentioning recent views, prefers to take the 1 inch map of the Geological Survey and the corresponding memoir as the basis of her work, many of the illustrations and several quotations from the latter publication being given.

Chap. ii (pp. 16–39) treats of the Carboniferous Limestone, and includes a long account of the swallows and underground streams so common in limestone districts. Many observations are open to criticism; for example, we are told (p. 17) that "it is unlikely that such a pure limestone could have been formed near a land area of any size." The word 'near' is not exact; but limestones are being laid down within distances of Continental coasts, which cannot be said to be far. Again, we learn that above Odin Fissure the shales are seen resting on the limestone with a junction which is called by geologists 'unconformable.' We have always regarded this section as evidence of a small landslip, for the shales are certainly not in place. At p. 19 we are told that carbonate of lime is soluble in water containing carbon dioxide or any acid. This is not chemically correct, for most acids decompose $CaCo_3$, and do not effect a simple solution. We look in vain for any account of the stratification of the limestone or the succession of its beds; indeed, the amount of stratigraphical geology in this chapter is very small, and palæontology suffers no less. The whole subject of the fossils is scamped; the few representations given had been better omitted. But we are informed that figures have been given "that the collector may have some idea

of their *original* appearance" (the italics are ours). The figures are somewhat grotesque libels on the fossils. Of what use can it be to depict *Productus giganteus*—Miss Dale prefers to keep the fossil feminine—as a shell 1¾ inch across? Or what peculiar characteristics of *Aviculopecten* are supposed to be demonstrated by fig. 16, which has not seemed worthy of a specific name? An error has arisen with regard to the shell called *Rhynchonella pugnus* (fig. 13), which is evidently *R. pleurodon*, and *Orthis resupinata* (fig. 14), which is probably a large example of *O. Michelini*, but is certainly not typical of the species it is supposed to represent. In all, eight specimens of various fossils are drawn on pl. iii, but only one has a specific name. We meet the curiously inexact statement that "of mollusca there are comparatively few. The bivalve forms are represented by several extinct species of *Pecten*, and by an extinct genus called *Aviculopecten*." We have been told on the same page that "all the fossils are the remains of animals now extinct." Further on, we are told that "a genus with a straight shell has been called *Orthoceras*." We would ask in all sincerity, is this the sort of thing which will help the study of geology? Palæontologists, however, need not despair, for Miss Dale, speaking of the Carboniferous sea, tells us (p. 39) that "at the surface and in the depths of this sea, lived and died countless numbers of animals such as man has never seen"; and in the orthodox higher flights of imagination with which certain authors have seen fit in the past to close their accounts of the geology of the Coal-measures, we are told (p. 104) that "on the ground beneath is a carpet of delicate green, composed of countless smaller ferns and unknown flowerless plants, amongst which dart lizards and now and then a scorpion." One is, however, tempted to ask Miss Dale if the imperfections of the geological record are really as great as we are led to infer from these excerpts.

Miss Dale prefers to call the shales and thin limestones between the grits and the massif of limestone, Yoredale, and to them devotes chap. iii (pp. 40–59). We note that she follows the old 1 inch Survey map, and regards the beds as of great thickness and assumes faults to account for any succession where there does not appear to be room for such a mass, e.g. along the line of the London and North-Western Railway. We are tempted to ask why similar faults are not necessary on the eastern limb of the anticline near Eyam, and further south between Youlgrave and the Grits or between the Grits and the limestone boundary at Matlock and Winster. Personally we think that the thickness of this series has been greatly overestimated. Is there also a series of Yoredale sandstones as well as Farey's grit? We regret that no continuous sections of these beds from the various brooks are given, but as in the description of the limestone, it does not seem to have been part of the authoress's plan to give any original account of the local geology. The palæontology of the shales, a subject of the highest importance, is only mentioned to be dismissed, and only one locality where "chiefly species of *Goniatites*, *Aviculopecten*, and plant-remains" were found is given. A careful search will reward the worker in

these beds, and a fairly large fauna, very widely spread, is to be found in them.

Chap. iv (pp. 60–84), on the Millstone Grit, strikes us as one of the best parts of the book, and included in it we find a brief account of the evolution of rivers. On p. 83 is a statement, however, which may cause misconception: "We know that even yet the Millstone Grit is of exceeding thickness, although thousands of feet have been removed by denudation." But Miss Dale surely does not mean that the Grit series was ever thicker than it is at present, i.e. between the limits of the base of the Coal-measures and the top of the Upper Limestone shales, and in the interest of accuracy one is tempted to ask—and surely one has the right to do so, for the book purports to be an introduction to the science of geology—how thick is an *exceeding* thickness? Miss Dale is fond of awe-inspiring superlatives. We are also told that the "Coal-measures once extended over the Pennine anticline." Did they? And where is the evidence for the great volcanoes which are said to have existed to the north-east and on the higher ground, round the swamps which became the coalfields?

Chap. v (pp. 85–105) treats of the Coal-measures at length; it discusses the fossil botany, various theories of the origin of coal, and the climate of the Coal period, and ends with a picturesque description of the scenery of the period. By the way, why are we told "over all the land and water hangs a thick pall of grey cloud"? Did not the Carboniferous flora require the aid of the sun to fix carbon? One plate of Coal-measure fossils is given; fig. 45 is said to be *Naiadites*, but the drawing has no resemblance whatever to any species of that genus; it may possibly belong to *Carbonicola*, though the drawing looks more like *Nuculana*. Fig. 47, a cast of the pith-cavity of the stem of a Calamite, is not very clear, because we do not quite see how the pith-cavity should bear fairly large branches; and should not the fish scale be spelled *Rhizodopsis* both in the plate and the text?

Chap. vi (pp. 106–127) deals with the Glacial Period, and we gladly appreciate Miss Dale's local work on this subject.

Chap. vii is devoted to post-Glacial deposits and early Man, and ends with an allusion to *Pithecanthropus erectus*.

Chap. viii deals with the development of geology and its relation to modern thought, and in our opinion is utterly out of place in a book of the kind. It is as equally unnecessary to allude to the past struggles between knowledge and those who demanded a literal interpretation of the Bible, as it is to talk in a volume which purports to be a description of local geology and scenery, of transcendental theology. *Timeo Danaos et dona ferentes*; somehow or other we distrust textbooks of science which have excerpts from religious books at the commencement.

The work of the book is unequal, here condescending to the almost pedantic explanation of terms, there dealing with theories which have little or no application in the Peak district proper, and we confess we cannot quite see for what class of reader this

discursive book is intended. "Of the making of books there is no end," and there is a real need for accurate and thorough work on local geology and scenery, but a treatise of very elementary theoretical geology is quite another thing. W. H.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—December 19, 1900.—J. J. H. Teall, Esq., M.A., F.R.S., President, in the Chair. The following communications were read :—

1. "On the Igneous Rocks associated with the Cambrian Beds of the Malvern Hills." By Prof. T. T. Groom, M.A., D.Sc., F.G.S.

The Cambrian beds of the Southern Malverns are associated with a series of igneous rocks which have commonly been regarded as volcanic, but are probably all intrusive. They consist of a series of bosses, dykes, sills, and small laccolites intruded into the Upper Cambrian Shales and into the Hollybush Sandstone. The dykes appear to be confined to the sandstones, the sills and laccolites chiefly to the shales, while the bosses are found in both. The rocks consist of a series of ophitic olivine-diabases, a related series of porphyritic olivine-basalts, and a series of porphyritic amphibole-bearing rocks of andesitic habit, but probably to be classed with the camptonites. The three types have a different distribution, and do not appear to be connected together by intermediate gradations; the amphibole-bearing and the olivine-bearing rocks differ in their mode of occurrence. According to existing analyses, the former range in chemical composition from sub-basic to basic, and the latter from thoroughly basic to ultrabasic. All the rocks have a local stamp, but are probably most nearly related to the camptonitic rocks of the Central English Midlands. Intrusion took place at a period not earlier than the Tremadoc, and probably not later than that of the May Hill Sandstone.

2. "On the Upper Greensand and Chloritic Marl of Mere and Maiden Bradley in Wiltshire." By A. J. Jukes-Browne, Esq., B.A., F.G.S., and John Scanes, Esq.

The district dealt with is on the borders of Wiltshire and Somerset. The general succession is as follows :—

	feet.
Lower Chalk, with Chloritic Marl at the base	200
Sands with calcareous concretions	3 to 8
Sands with siliceous concretions (cherts)	20 to 24
Coarse Greensand	15
Fine grey and buff sands	about 120
Sandy marlstone	15
Grey marl and clay (Gault)	90

The chert-concretions and the sands in which they occur consist very largely of spicules of lithistid sponges. One of the sandstone-beds has yielded several species of *Necrocarcinus*, and may be the

chief source of the crustacea which have been quoted from the Warminster Greensand. Above the chert-beds, and below the horizon at which *Stauronema Carteri* comes in, is a variable set of beds which include a layer of concretions known as cornstones or popple-stones. These beds are very rich in fossils, and include at Maiden Bradley a layer of phosphatic nodules. They contain the Rye Hill fauna of the Warminster Greensand, and it is proposed to call them the zone of *Catopygus columbarius*. In Southern Wiltshire there is usually a complete passage from this zone into the Chloritic Marl; and as the cephalopoda of this zone are all Chalk Marl species, the natural inference from the local evidence would be to place the plane of separation between the Selbornian and Cenomanian stages at the base of the *C. columbarius* beds. In Dorset, however, the break above these beds is so very marked and strong that the authors think that the beds with the Rye Hill fauna must be retained in the Selbornian. It is one of those cases in which the palæontological and the stratigraphical breaks do not coincide.

II.—Jan. 9, 1901.—J. J. H. Teall, Esq., M.A., F.R.S., President, in the Chair. The following communications were read:—

1. "The Geology of South-Central Ceylon." By John Parkinson, Esq., F.G.S.

In this communication the author endeavours to give some account of the relations between the various granulitic rocks of Ceylon. A series of more or less isolated sections were studied, the rocks in each considered under separate heads, and conclusions put forward relative to the whole. Two sections are described to the west, and one to the north, of Kandy, in which the rocks are of a well-marked type. As a rule they are strongly, often coarsely, banded; and the relation of the light and dark bands is such as to leave the author to conclude that this structure arose "through the streaking together of the component parts of a magma which had undergone differentiation." The darker parts are characterized by the presence of green hornblende in varying quantity, associated with brown mica. Locally garnets are abundant, and pyroxene is found in some slides. A fourth section, south of Matalé, is of importance, since it is believed that here a granulitic rock resembling some described under the section which follows (Section V) is intrusive in a crystalline limestone. Modifications in the intruder are described, which are supposed to have arisen through the local incorporation of some of the older rock. Under Section V rocks from Newara Eliya, Ohiya, and Bandarawella are grouped together. These are often banded and vary considerably in coarseness, but are distinguished, with few exceptions, by a greenish colour accompanied by a greasy lustre, and usually by the presence of garnet. Hornblende, magnetite, and biotite are associated with this mineral, and a pleochroic augite is not uncommon. The structure of all the rocks described is granulitic; that is, characterized by the irregularity in the outlines of the grains which

build up the rock, and by the inclusion of one mineral by another. Porphyritic felspars are recorded from several localities.

The author concludes that the rocks of Section V are nearly related to those described in the earlier part of the paper, and points out the close resemblance of the whole to the Charnockite Series of Southern India.

2. "Note on the Occurrence of Corundum as a Contact-Mineral at Pont-Paul, near Morlaix (Finistère)." By A. K. Coomára-Swámy, Esq., B.Sc., F.L.S., F.G.S.

The intrusive granite of Pont-Paul, near Morlaix, contains highly altered fragments of sedimentary rock. The minerals found in them are biotite, muscovite, corundum (first recorded by Professor Barrois in 1887), plagioclase, andalusite, pyrite, magnetite, sillimanite, green spinel, and zircon. The corundum forms sharply idiomorphic tabular hexagonal crystals, striated and slightly stepped on the basal plane, and blue in colour. Iron-oxide is a constant inclusion. The inclusions have probably been to some extent injected with felspathic material. The original sediment was probably poor in silica and rich in alumina, and there has been sufficient molecular freedom for the formation of well-shaped crystals of corundum, comparatively free from inclusions. Sillimanite and zircon are the only other minerals which exhibit crystalline form.

CORRESPONDENCE.

YORKSHIRE BOULDERS.

Sir,—The value of Mr. Stather's paper on the sources and distribution of Yorkshire boulders (p. 17), which is very great, is not enhanced by the concluding paragraph. The Scandinavian Ice-sheet seems to affect some geologists as King Charles' head did Mr. Dick. May I then ask Mr. Stather two questions:—(1) What route did the Scandinavian Ice-sheet take when it anticipated the Norsemen by invading England? (2) What caused it to retreat before the advance of the British Ice-sheet? It was no doubt very polite to give place to the 'weaker vessel,' but as the British hill districts are smaller than and to the south of the Scandinavian, I should have thought nature would not have allowed courtesy to supersede law.

T. G. Bonney.

OBITUARY.

FREDERICK WILLIAM EGAN, B.A.

Born July 31, 1836. Died January 6, 1901.

Mr. Egan was born in Dublin on July 31st, 1836, and was the third son of the late Mr. W. J. Egan, of Rockville, Dundrum. Receiving his early education at Mr. Flynn's school in Harcourt Street, he entered Trinity College, where in due course he took

his degree of B.A. and a diploma in Engineering. Commencing professional life as a railway engineer, he did considerable work in connection with the Great Northern, Great Southern, and Dublin, Wicklow, and Wexford Railways, then in course of construction, In 1868 he quitted the somewhat desultory employment of railway engineer for a more permanent position on the staff of the Geological Survey of Ireland, being appointed assistant geologist on the nomination of the late Professor Jukes, F.R.S. In 1890 he was promoted to the grade of geologist on the recommendation of the present Director-General of the Survey, Sir A. Geikie, D.C.L., F.R.S. His work was always characterized by the great care he bestowed on it, no details being too insignificant for his attention, and while he did not seek fame as an independent essayist, his contributions to the Official Memoirs and other reports furnish a mass of information which has often proved of considerable economic value. In the Summer of 1899 he met with an unfortunate accident, being violently thrown off a car while travelling in the execution of his duties, and sustained severe injuries, from which he never fully recovered. Some six months ago his complaint assumed a malignant form, which terminated in his death, after a long period of much suffering, on the 6th January. In personal character Mr. Egan was one of the kindliest and most lovable of men, and beyond the circle of his own family and immediate friends none will regret his loss more than his colleagues of the Geological Survey, to whom he was much endeared by his unfailing amiability, obligingness, and thorough good-nature.—*Irish Times*, January 11th.

MISCELLANEOUS.

The Director-General of the Geological Survey of the United Kingdom.—The announcement has just reached us (January 15th) that Sir Archibald Geikie has intimated his intention to retire from the post of Director-General of the Geological Survey of the United Kingdom, an office which he has so ably filled for the past twenty years, on March 1st next. In 1855, at the age of 20, Sir A. Geikie became an Assistant on the Geological Survey of Scotland, and he was made Director for Scotland in 1867. In 1881 he was appointed to succeed Sir Andrew Ramsay as Director-General of the Geological Survey of the United Kingdom. He has seen forty-six years' service, but is now only in his 66th year. (See his life, Geol. Mag. 1890, p. 49.) Early in March he will be entertained by his friends at a complimentary dinner. All who wish to attend should communicate with Mr. F. W. Rudler, Museum of Practical Geology, 28, Jermyn Street, London, S.W.—We rejoice to learn that Sir A. Geikie has no intention of retiring from active participation in geological work, and that neither his hammer nor his pen are to be laid aside for some years to come.